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A Summary of Current Program and  
Preliminary Report of Progress

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FLORIST, NURSERY AND SHADE TREE RESEARCH

of the

United States Department of Agriculture  
and Cooperating Agencies

This progress report of U.S.D.A. and cooperative research is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of progress on U.S.D.A. and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having an interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of U.S.D.A. and cooperative research issued during the past year. Current agricultural research findings are also published in the monthly U.S.D.A. publications, Agricultural Research, Agricultural Marketing, and The Farm Index.

UNITED STATES DEPARTMENT OF AGRICULTURE

Washington, D. C.

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## ADVISORY COMMITTEES

The research program of the Department of Agriculture is reviewed annually by the following advisory committees:

1. Farm Resources Research
2. Utilization Research and Development
3. Human Nutrition and Consumer Use Research
4. Marketing Research and Service
5. Agricultural Economics Research
6. Forestry Research
7. Animal and Animal Products Research
8. Cotton and Tobacco Research
9. Grain and Forage Crops Research
10. Horticultural Crops Research
11. Oilseed, Peanut and Sugar Crops Research

## ORGANIZATIONAL UNIT PROGRESS REPORTS

The source materials used by the advisory committees are of two types. First, there are Organizational Unit Reports that cover the work of the Divisions or Services listed below. The number prefixes refer to advisory committees listed above that review all of the work of the respective Divisions or Services.

### Agricultural Research Service (ARS)

- 1 - Soil and Water Conservation
- 2 - Utilization -- Eastern
- 2 - Utilization -- Northern
- 2 - Utilization -- Southern
- 2 - Utilization -- Western
- 3 - Human Nutrition
- 3 - Clothing and Housing
- 3 - Consumer and Food Economics
- 7 - Animal Husbandry
- 7 - Animal Disease and Parasite

### Agricultural Marketing Service (AMS)

- 4 - Market Quality
- 4 - Transportation and Facilities

### Economic Research Service (ERS)

- 4,5 - Marketing Economics
- 5 - Farm Production Economics
- 5 - Resource Development Economics
- 5 - Economic & Statistical Analysis
- 5 - Foreign Development and Trade Analysis
- 5 - Foreign Analysis Division

### Other Services

- 1 - Soil Conservation Service (SCS)
- 4,5 - Farmer Cooperative Service (FCS)
- 4,5 - Statistical Reporting Service (SRS)
- 6 - Forest Service (FS)

Three organizational unit reports are not reviewed in entirety by any one committee. All of the information in them is included in the subject matter reports.

Agricultural Research Service (ARS)

Agricultural Engineering  
Crops  
Entomology

SUBJECT MATTER PROGRESS REPORTS

The second type of report brings together the U.S.D.A. program and progress for the following commodities and subjects:

- |  |   |
|--|---|
| 1 - Cross Commodity Research of<br>Agricultural Engineering, Crops,<br>& Entomology Research Divisions | 7 - Cross Specie & Miscellaneous<br>Animal Research |
| 3 - Rural Dwellings  | 8 - Cotton and Cottonseed                           |
| 6 - Forestry (Other than Forest<br>Service)  | 8 - Tobacco   |
| 7 - Beef Cattle  | 9 - Grain and Forage Crops                          |
| 7 - Dairy  | 10 - Citrus & Subtropical Fruit                     |
| 7 - Poultry  | 10 - Deciduous Fruit & Tree Nut                     |
| 7 - Sheep and Wool   | 10 - Potato   |
| 7 - Swine  | 10 - Vegetable                                      |
|  | 10 - Florist, Nursery & Shade Tree                  |
|  | 11 - Oilseed and Peanut                             |
|  | 11 - Sugar  |

A copy of any of the reports may be requested from Roy Magruder, Office of Administrator, Agricultural Research Service, U. S. Department of Agriculture, Washington 25, D. C.

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## INTRODUCTION

This report deals with research on flowers, nursery plants; shade, ornamental and windbreak trees. It does not include extensive cross-commodity work, much of it basic in character, which contributes to the solution of problems of other agricultural commodities, as well as those of flowers, nursery plants; shade, ornamental and windbreak trees. The progress on cross-commodity work is found in the organizational unit reports of the several research divisions of the Department.

This report is organized by problem areas which are shown as the major subjects under the three main divisions in the table of contents. For each of the problem areas there is a statement of (1) the Problem, (2) USDA PROGRAM, (3) REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS for the past year, and (4) PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH.

Research on flowers, ornamentals and shade trees is supported by (1) Federal funds appropriated to the research agencies of the USDA, (2) Federal and State funds appropriated to the research agencies of the USDA, and (3) private funds for research carried on in private laboratories or for support of State Station or USDA work.

### Research by USDA

Farm Research is conducted by the Crops and Entomology Divisions of the Agricultural Research Service. It comprises investigations on introduction and evaluation, breeding, disease control, culture, classification and identification, weed, nematode and insect control. In fiscal year 1963, the work involved about 29 professional man-years.

Marketing and Economic Research is conducted by the Agricultural Marketing Service. The physical, biological and economic aspects of quality maintenance in handling and packaging, in storage and during transportation as well as post harvest physiology are investigated by the Market Quality Research Division, and involved one professional man-year in fiscal year 1963. Work on merchandising and promotion practices for floral products is done by the Marketing Economics Division. In fiscal year 1963, the work involved three professional man-years.

### Interrelationships Among Department, State and Private Research

Much of the Department's research is cooperative with State Experiment Stations, various sectors of industry and with growers. Cooperative work is jointly planned and frequently participated in by Federal, State and industry workers. The nature of the cooperation varies with each study. It is developed to fully utilize the personnel and other resources

## INTRODUCTION (Cont.)

of the cooperators. There is regular exchange of information between State and Department scientists to assure that the research programs complement each other and eliminate undesirable duplication. Many Department employees are located at State Stations and use laboratories and office space close to, or furnished by, the State.

Privately supported research of considerable extent is done by container and equipment manufacturers and suppliers, chemical and fertilizer companies, market research institutes and corporations, nurserymen, florists and their associations and research institutes. Industry's cooperation in supporting research on flowers, ornamentals and shade trees in the form of grants, gifts, or loans of materials, equipment and facilities to Federal and State stations has contributed greatly to its success.

Marketing equipment and facility manufacturers make sizeable contributions to research in the development of equipment for handling flowers, ornamentals and shade trees in greenhouses, storages, retail and wholesale establishments, and in transportation vehicles in which it moves from one point to another in the channel of distribution as well as on the containers in which it moves. Market research institutes and others in marketing economics research are largely concerned with research in consumer preference, market potentials, market promotion and development and interregional and intermarket competition.

Chemical, fertilizer and electrical equipment companies are significant factors in research on the development of new materials and equipment or combinations of these to produce more efficiently, high quality flowers and ornamentals through better nutrition, control of diseases, insects, nematodes, and weeds and through the regulation of growth processes through the use of growth regulator substances, light and environmental control equipment.

A number of the larger florists, seedsmen, bulb growers and nurserymen spend considerable time and money in breeding and testing new varieties of flowers and ornamentals in the major production areas, sometimes on their own acreage but much of it usually in cooperation with smaller growers. The contribution of growers to the overall research effort is considerable. Certainly in the field of production his help is indispensable for much of the laboratory research results must be confirmed in the nursery and greenhouse in each of the major production areas. The grower cooperates with the USDA, State Experiment Stations and suppliers of many materials and equipment - usually without compensation except for the experience and knowledge gained.



## I. FARM RESEARCH

CROP INTRODUCTION AND EVALUATION  
Crops Research Division, ARS

Problem. One of the important needs in a more efficient agriculture is the introduction and/or development of improved plants with resistance to insects, diseases, nematodes and with increased adaptation and higher quality. There is a need to search out, introduce, maintain and evaluate as rapidly as possible, the world's resources of flowers, ornamentals and shade trees that may be of value as varieties or breeding materials.

## USDA PROGRAM

The Department undertakes a continuing program of plant introduction, evaluation and maintenance. The research involves botanists, horticulturists and plant pathologists who are engaged in both basic and applied studies that will provide plant scientists and others with documented germ plasm.

Plant introduction is undertaken in both foreign and domestic fields, either through direct exploration or international exchange. Taxonomic and economic botanical research on world plant resources, development of national inventories of introduced stocks, coordination of foreign and domestic plant collecting, and botanical assessment of the results of crop utilization screening programs are conducted at Beltsville. Cooperative arrangements with the four regional projects provides for domestic explorations.

Evaluation of flowers and ornamentals is done at Beltsville and Glenn Dale, Maryland; Experiment and Savannah, Georgia; Miami, Florida; Chico, California; Geneva, New York; Ames, Iowa; and Pullman, Washington. It involves observations for specific characters needed in varietal improvement, the maintenance of collections of important foreign varieties, and limited increase to provide material for testing purposes. Regional station pathologists screen the introductions for disease tolerance. Federal, State and private breeders cooperate in the early evaluation of introductions. Needs for additional breeding stocks are assessed by the research leaders at Beltsville and become the basis for future plant exploration and introduction.

The Federal scientific effort devoted to introduction and evaluation of flowers and ornamentals was 3.7 professional man-years.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

An exploration to Nepal, as part of the ARS - Longwood Gardens cooperative ornamental program, resulted in 230 collections of ornamental trees, shrubs, and herbaceous plants, many of which were introduced to the U. S. for the first time. A collecting trip in Oregon and Washington, as a part of the W 6 regional program, resulted in numerous selections of native *Ceanothus* for trial for erosion, roadside cover and landscape purposes.

The majority of new ornamental introductions have resulted from a series of explorations sponsored by a cooperative program of ARS and Longwood Gardens, Kennett Square, Pennsylvania. Evaluations of these and other introduced ornamentals by cooperators of State Experiment Stations and similar institutions form the basis of recommendations for releases to the nursery trade.

The Montana Agricultural Experiment Station's research workers have selected six of the 1956 Japanese chrysanthemum introductions as parents for use in breeding chrysanthemum strains with florist-type flowers. A seedling ('Susan Leight' X P.I. 235927) will be released to the trade in the near future. Four summer-flowering, virus-free Japanese chrysanthemums under test at Bozeman, Montana, show promise as early garden varieties sufficiently winter hardy to withstand climatic conditions in that area. 'Kinkazan' (P.I. 231099) is a profusely flowering, deep yellow pompon type with vigorous growth and strong stems; 'Hinomaru' (P.I. 231096) is an attractive lavender-pink pompon, well-liked type except for its tendency to produce weak flower stems; 'Shinmisono' (P.I. 231100) is a lavender purple pompon type of good quality with strong stems; and 'Tsukase' (P.I. 231102) is a white double-flowered type with erect growth habit, 20 inches tall, and stiff flower stems. 'Kinkazan' is well liked in North Carolina, Oklahoma, Texas, Virginia; 'Hinomaru' is liked in Louisiana, North Carolina, and South Carolina. (W-6). After four years of testing at the North Platte Experiment Station, the

Nebraska Agricultural Experiment Station released to the trade the Japanese chrysanthemum varieties; 'Virgin Elegance' (P.I. 235624) a deep purplish-red, heavy blooming, upright, stiff-stemmed variety 30 inches in height and outstanding for flower-color retention even at high temperatures; 'Blue Sky', (P.I. 235627), which bears pure white flowers 2-1/2 to 3 inches in diameter, dense clusters suitable for cutting. 'Blue Sky' is unusually frost tolerant for a white variety. Both varieties are cold hardy and early enough to be dependable in their flowering.

Two introductions of *Eurya*, P.I. 235425 (Japan) (*E. emarginata*) and P.I. 240914 (Japan) (*E. emarginata* var. *microphylla*), distributed by the Glenn Dale Plant Introduction Station in recent years, have



received favorable comment by cooperators in the southeastern states who indicate that given protection these introductions show considerable promise as semi-dwarf evergreens for rock gardens and where low shrubs are required.

The Proteaceae of South Africa contain many handsome shrubs which bear large attractive flowers. Seedlings of seven 1961 introductions are under evaluation at the U. S. Plant Introduction Station, Chico, Calif. Three introductions, Leucadendron galpinii (P.I. 273807), L. dregei (P.I. 273806), and L. sp. (P.I. 273809), withstood 15°F in January 1963 with relatively little injury. L. dregei bears attractive large pink cones, has dark green foliage, and has a low, spreading shrub-like growth habit which makes it suitable for foundation planting. L. galpinii is an interesting conal fruited novelty but not as handsome as L. dregei. Evaluation of this seedling collection will be continued for several years before planning a wider test throughout the southwest of those considered most promising.

Of 27 seedlings of Dombeya elegans planted at the Miami Plant Introduction Station in October 1961, 16 flowered this season exhibiting considerable variation for so small a population. Flower color on most plants was identical to the parent plant, but two plants bore flowers of a dark rose which was even more outstanding than the pink color of the parent. Although cuttings are difficult to root, a successful method has now been developed. This plant produces large clusters of flowers on the periphery of the plant; it holds much promise as a pot plant for the florist trade or as a small ornamental tree.

#### PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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- Ackerman, W. L. 1962. Interspecific Hybridizing of Camellias. American Camellia Yearbook.
- Loomis, H. F. 1962. Landscape Grouping of Palm Species. Tropical Living 13(1): 14-15.
- Soderholm, P. K. 1963. Ipomoea walcottiana - the tree morningglory. Amer. Hort. Mag. April.
- Whitehouse, W. E., J. L. Creech, and G. A. Seaton. 1963. 'Bradford' Ornamental Pear - A Promising Shade Tree. American Nurseryman. April 15.
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FLOWER AND ORNAMENTAL PLANT CULTURE,  
BREEDING AND GENETICS, DISEASES AND VARIETY EVALUATION

Problem. Because of the hundreds of kinds of ornamental and floricultural crops in commerce, (farm value over 1/2 billion dollars) and the diversity of them grown in every State under both greenhouse and open garden or field conditions, the kinds of technical problems of economic interest are varied and numerous. Until recent years little research was conducted as a basis for efficient and effective production of ornamentals for any purpose. The backlog of untouched problems in the culture, propagation, nutrition, physiology, photoperiodicity, genetics, breeding, pathology and adaptabilities of these plants is rather appalling. Members of the industry have been until relatively recently rather secretive about their production troubles, but now the multitude, magnitude and economic costs of many of them are becoming apparent. The recent expansion of cut flower production out-of-doors for air and other fast shipment to distant market is attended by many new problems. Explosive urbanization and expanding interest in civic beautification bring new needs and more urgent needs for answers to old problems. Here is a group of crops for which the capacity to consume is highly elastic and which merit great expansion of use.

USDA PROGRAM

The Department has a continuing long-term program involving geneticists, physiologists, plant pathologists and horticulturists carrying on both basic and applied research on many problems concerned with production of floricultural and ornamental plants. Breeding and genetics are being done at Beltsville, Maryland, at the National Arboretum, Washington, D.C., and at Tifton, Georgia, in cooperation with the Georgia Coastal Plain Experiment Station.

Research on diseases is located at Beltsville, Maryland, and is cooperative with the Georgia Coastal Plain Experiment Station, Tifton, Georgia; the Oregon Agricultural Experiment Station, Corvallis, Oregon; the Western Washington Experiment Station, Puyallup, Washington; and the West Virginia Agricultural Experiment Station, Morgantown, West Virginia. Experiments improving cultural methods are carried on at Beltsville, Maryland, and in cooperation with the Stations at the locations just named.

Reference collections of living plants and herbarium specimens are maintained at the National Arboretum, Washington, D.C. Promising selections from foreign introductions received through the New Crops Research Branch are propagated at the Arboretum for testing and for distribution to other botanic gardens, arboreta



and experiment stations. Plant specimens are identified and classified.

A contract with the Ministry of Agriculture, India, provides for the studies of pyridinonucleotide metabolism in normal and tumor tissue of hollyhock. The contract is for the five years, 1963-1967, and involves PL 480 funds with a \$36,666 equivalent of Indian rupees.

The Federal scientific effort devoted to research on ornamentals totals 16.3 professional man-years. Of this number 6.2 is devoted to breeding and genetics, 2.7 to diseases, 3.1 to variety evaluation and classification, 4.0 to culture, and 0.3 to program leadership.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

##### A. Breeding

1. African violet. Progenies of over 200 interspecific crosses were potted in 2-inch clay pots for evaluation. The foliage of immature hybrids show characters somewhat intermediate between the parents. No differences were noted between reciprocal crosses. Of 25 progenies which flowered so far, the size and color of flowers were also intermediate. Mutant colors such as red, pink, and white from commercial cultivars were recessive to the wild-type, blue-violet colors.

2. Azaleas. The study of seedling populations from crosses of dwarf x dwarf and dwarf x normal is continuing into the fourth year. It appears that the type of growth which the mature plant will produce can be determined within this time, but many of the more dwarf types have not flowered in the fourth year. The program of out-door selection for good, dark red-flowered, standard varieties continued. Plants showing no cold injury have been propagated for further trial. Further backcrosses have been made with the deciduous x evergreen hybrids in the attempt to bring hardiness and yellow color from the deciduous types into evergreens. Additional seedlings have been obtained from crosses with broad, glossy leaved Rhododendron species and hybrids.

3. Camellias. The winter of 1962 - 63 provided an excellent cold hardiness test for camellias. A low of plus one degree F. was recorded on two separate occasions. High winds and a soil frozen to a depth of 4 to 8 inches attributed to the winter injury observed. Approximately 150 varieties of Camellia japonica were evaluated and only the following varieties produced flowers, most of which were fair to poor in quality: 'Berenice Boddy', 'Magnolia-flora', 'Gov. Mouton', 'Marjorie Magnificent', 'Dr. Tinsley', 'Ville de Nantes', 'Flame', 'Imura', 'Leucantha', and 'C.M. Hovey'.

Foliage "burn" was severe on C. rusticana, most varieties of C. sasanqua and many varieties of C. japonica. There was little or no damage to the foliage of C. oleifera. A number of unnamed seedlings of C. japonica, as in previous years, showed superior flower bud and foliage hardiness over named varieties.

4. Carnation. Several thousand new carnation seedlings were grown to flowering. They were selected for horticultural promise and for study of genetic factors. After five backcrosses to the commercial carnations, a hybrid with a Dianthus species produced some seedlings of reasonable commercial size. However, the high production of flowers seems to be reduced by progressive backcrossing. Further crosses to several Dianthus species have produced seed.

5. Chrysanthemums. Ten new selections of promising chrysanthemum seedlings were made and are being propagated for further trial. Seven chrysanthemum seedlings were named and released to nurserymen.

6. Crapemyrtle. During the year 251 accessions have been added to the Lagerstroemia research collection. A large number of these are dwarf seedling selections. No additional hybridization was undertaken. From the 127 crosses made in 1960 between L. indica cultivars 3000 seedlings have been raised. Seedling flowering was moderate last year but by another season rigid selection should be possible. A number of seedling selections have been made for further evaluation. From 6 colchicine seed and seedling treatments a population of 1058 plants have been raised. Less than one percent of the seed included in 8 irradiation treatments germinated. The survival plants appear to be dwarf, but are not of sufficient size for critical evaluation. Three plants of each L. indica cultivar accession were procured or propagated three years ago and established in a trial evaluation block.

7. Dianthus. None of the Dianthus released by the Cheyenne Station survived the open winter at Mandan, N.D., which lacked any snow cover. Privately owned stock of similar species planted nearby and mulched with hay came through the winter in good condition.

8. Gladiolus. Seedlings of collections of species from Africa are being grown to flowering size, as well as seedlings from inter-specific pollinations for evaluation as potential parents.

9. Hemerocallis. (a) Temperature effect on seed set. Seed set studies using six daylily cultivars and 6-hour exposure to 3 temperatures, 75°, 85°, and 95°F, immediately after pollination showed that 75° was better than 85° or 95° for setting seeds. The tests showed that seed set in daylilies is influenced also by the combinability of the crosses. Certain crosses produced more seeds at all temperatures than others. Self-pollination resulted in lower seed



set than cross-pollination at all temperatures.

(b) Forcing daylilies. Six mid-season daylily cultivars of evergreen, semi-evergreen, and deciduous types were forced at 75° at 3 different photoperiods after cold treatment from 5 to 11 weeks at 40°. Photoperiods were natural days, natural days plus 4 hours in the middle of the night, and natural days plus interruption with 1, 2, 3, and 4 hours during successive weeks. Comparisons based on the number of days to first flower showed that long days were superior to natural days for forcing. Daylilies forced by gradually lengthening the daylength over natural days bloomed earlier than those under natural days but later than those under long days.

(c) Temperature treatments affecting flowering. There were only small differences in time of bloom due to cold treatment of plants. Statistical analysis showed that 5 and 7 weeks at 40°F were superior to 9 and 11 weeks. Evergreen, semi-evergreen, and deciduous cultivars all showed about the same response to daylength and cold.

10. Herbaceous perennials. Blocks of herbaceous perennials of potential genetic value were maintained and a summary of all herbaceous perennials tested at the Cheyenne Station is now being prepared.

11. Hibiscus. A total of 385 accessions have been added to the Arboretum Hibiscus research collection during the year. A large number of these have been H. rosa-sinensis cultivars for screening for parental seed lines. Plants were procured or propagated 3 years ago to establish a trial evaluation block of H. syriacus cultivars. These plants will provide stock for hybridization and detailed evaluation data that establishes a basis for the registration of cultivar names.

Much of the hybridization has been centered around H. rosa-sinensis, H. syriacus, and the Hawaiian species. Of 195 H. rosa-sinensis selfs, 44 produced seed, but only 12 of 117 crosses produced seed. From a total of 280 crosses involving H. syriacus (diploids and tetraploids) and H. rosa-sinensis none have matured viable seed. A number of these crosses yield a partially developed seed in the capsule. Embryo culture techniques may prove effective in obtaining plants from this diverse cross. From 30 H. syriacus x H. syriacus crosses made in 1960 a seedling population of 1962 seedlings have been grown. Another 4500 seedlings have been raised from self- or open-pollinated seed. Flowering was moderate on these seedlings last year, but rigid selection should be possible this season.

Tetraploid H. syriacus plants have been recovered from the surviving 442 plants of 6 colchicine treatments. 720 seedlings have been grown from 8 seed irradiation treatments. A number of variations

were noted in the first generation irradiated plants. A second generation seedling population of 3000 plants now being grown in the greenhouse should reveal the range of recombination types that resulted from irradiation.

By cytological study of Hibiscus the chromosome numbers have been determined for the following: H. ludwigii  $2n = 40$ ; Hawaiian hibiscus diploid ca.  $2n = 80$  - 7 species, tetraploid ca.  $2n = 160$  - 1 species; unidentified species ca.  $2n = 100$ , H. sinosyriacus ca.  $2n = 80$ ; H. syriacus colchicine treated seed plants diploid ca.  $2n = 80$  - 5 plants, tetraploid ca.  $2n = 160$  - 10 plants.

12. Hollies. Hybridization of Ilex aquifolium with a few of the Asiatic species has produced promising combinations. These hybrids are being propagated for initial evaluation in comparison with standard cultivars. As a result of the past winter's low temperature (plus  $2^{\circ}\text{F}$ ), it was possible to evaluate some species and interspecific hybrids for winter hardiness under similar growing conditions.

Ilex x 'Nellie R. Stevens' has proved exceptional in that it is winter-hardy, heat-tolerant, and will tolerate poor drainage. This is a Chinese-English hybrid female cultivar. Ilex sugeroki, collected in Japan, has proven hardy during the last two seasons. P.I. 230455, a small-leaved, red-berried evergreen introduction, may offer similar possibilities for use in the landscape as black-berried I. crenata. Additional data has been secured this year on sex inheritance; however, all progenies have not reached mature flowering stage. The final report necessarily must be carried over until next year.

13. Lilies. (a) Tetraploids. Four tetraploid clons of Easter lilies were selected for increase and introduction from the 25 clons forced in the large trial in 1961-62. Planting stocks of the four clons are being increased by the research project at three locations and under memorandums of understanding with two growers in Florida and one in Oregon.

(b) Triploids and hexaploids. Several triploid Easter lilies obtained by crossing tetraploids with diploids are being increased at Tifton, Ga., Arthurdale, W. Va., and Beltsville, Md., to produce bulbs for a comparative forcing trial next year. Several of the triploids were treated with colchicine and plants that appeared to be affected were examined cytologically and found to be hexaploids, with 72 chromosomes.

(c) Interspecific lily hybrids. The interspecific hybrid L. longiflorum x L. formosanum has flowered, as has the amphidiploid produced by colchicine treatment. The hybrid and its amphidiploid are very vigorous; their blooming dates are intermediate between



L. longiflorum and L. formosanum. Unfortunately the hybrid and its amphidiploid are both as susceptible to mottle mosaic as the L. formosanum parent. Backcrosses to both parents have been made and these should bloom this year. The chromosomes of the parent species have identical morphology and pairing in meiosis was very regular. Hybridity was determined from morphological characters and the intermediate date of blooming.

A hybrid sent by a private lily breeder was found, by study of the chromosomes, to be L. speciosum punctatum x L. henryi. The hybrid has, for many years, consistently failed to set seed by self- or cross-pollination. Pollen of the hybrid produced 156 seeds when used in the greenhouse on 34 flowers of L. speciosum album, and 101 seeds on nine flowers of L. speciosum rubrum. The seeds all germinated on nutrient agar. These are new combinations of species in Lilium and should lead to some valuable new forms of garden lilies.

(d) Endosperm breakdown as barrier to hybridization. An investigation is underway to determine the timing and cause of the breakdown in the endosperm of seeds formed when L. speciosum album is crossed with L. auratum. In this abnormality in the endosperm, the embryos are eventually destroyed and some form tumors. Examination of endosperms at various times after pollination have revealed early death of cells and formation of giant cells containing from 3 to 7 nuclei. Such cells were found in areas surrounded by decomposed endosperm tissue.

(e) Lily Inbreds. Inbred lines of several clons of L. longiflorum are being developed by continued self-pollination. Two clons are self-incompatible, but set a few seeds when treated with 2 percent naphthalene acetamide at time of pollination. It is hoped to establish homozygous lines and then produce uniform hybrids from seed.

14. Magnolias. In spite of the severe winter, the majority of magnolia species and hybrids flowered normally with no apparent winter injury in the Arboretum collection. Outstanding for its first-season flowering was a 10-year-old plant of Magnolia sprangeri diva. This relatively unknown Chinese species was received from England. It flowers before the leaves appear, with large rose-pink flowers having 12 tepals. Its value in breeding bright pink, hardy, tree-sized magnolias will be exploited.

Many hybrid magnolias performed poorly this year due to the drought last summer. Further evaluation will be made next season.

15. Ornamental trees. At Mandan, N.D., grafting material of one thornless Gleditsia triacanthos selection, which has proved hardy, was forwarded to the North Central Regional Plant Introduction Station for wider testing. One columnar-type hybrid elm at Mandan was



budded on a number of the hardy Harbin elm seedlings to provide a stock preparatory to releasing to the commercial trade.

Observations of selections of hardy deciduous and broadleaved shrubs and coniferous trees continue at Woodward, Okla. Considerable losses of seedling selections of Cupressus arizonica were due to bad weather. Grafts of several winter-hardy forms of this species on both red cedar and Chinese arborvitae roots still show considerably more promise than some of our seedling selections.

16. Pieris. Research has been somewhat curtailed because of damage to stock plants by an unintentional application of lime and by freezing conditions. The plants will require another season in order to be of suitable size and vigor to produce flowers for hybridization. During the year an additional 17 accessions have been added to the Pieris research collection.

17. Poinsettia. (a) Genetic studies. Two independent loci determining bract color have been identified. Homozygous recessive at one locus, ww, is white. Homozygous recessive at the second locus, pp, is salmon pink. The double recessive is white. Two selections of the pink lines have been sent out for commercial trial. The distorted growth in a "pink" seedling of the constitution WwPP has been inherited, apparently as a single factor difference. One F<sub>1</sub> plant which is distorted and was red, has produced a branch which is the same "pink" as the P<sub>1</sub>. Genetic analysis of the F<sub>1</sub> sectors and of sectors which appeared in the P<sub>1</sub> plant has been started. A red sector on the P<sub>1</sub> plant remained WwPP.

(b) Tetraploids. Backcross progeny of tetraploids heterozygous at the white locus, to white tetraploids, gave the expected 5 to 1 ratio of red and white seedlings. Test crosses of these seedlings have identified plants carrying 1 or 2 chromosomes with the "W" allele and 3 or 2 chromosomes with the "w" allele. Attempts are underway to use these plants to identify the genetic influence other than bract color, of this chromosome.

Breeding at the tetraploid level has continued with little apparent success in the attempt to separate an undesirable cupping of bracts from the tetraploid condition. In the third and fourth generation tetraploids there has been some segregation of the shades of red and white so evident in the diploids.

(c) True breeding poinsettias from seed. Further selections were made and crosses carried out to develop true-breeding lines of commercial quality. Progress in this direction gives some indication that it may become possible to grow the commercial crop from seed. Selections have also been made of dwarf and of cold resistant plants for outdoor use in the South. These will be tested at Tifton, Ga.,

next season.

18. Pyracantha. The field evaluation planting of three plants of each Pyracantha accession has been established. Many of these plants are now of sufficient size to produce heavy flowering and fruiting. An additional 12 accessions have been added to the Pyracantha research collection.

Plants for hybridization have been grown as standards. The stock plants were moved to the greenhouse in order to control temperature and facilitate hand pollination work. A total of 378 crosses and 53 selfs were attempted. The fruit set has been good, but the complete data has not yet been recorded. An attempt has been made to obtain all possible combination crosses between species. Additional select cultivars and species have been hybridized with the goal to recombine the ornamental characteristics of several species into one plant. A number of crosses were attempted with the possibility that such crosses would provide information on the taxonomic relationship of species.

19. Redbud. An additional 5 accessions have been added to the Cercis research collection during the year. 5 of the hybrid C. canadensis x C. chinensis have been selfed and a seedling population of 860 plants lined in the field. A portion of the seedlings flowered this season, and several noteworthy selections were made. These plants require additional evaluation. Several Cercis crosses were attempted in the greenhouse, but no seed has been produced.

20. Rhododendrons. Varietal test plantings have been expanded by addition of a second contribution of 200 flowering-sized plants from the Gotelli collections. 35 selections of R. fortunei hybrid have been transplanted for further observation. Initial selections have been made from seedlings of R. dauricum x pemakoense and progenies of numerous additional crosses are being grown to flowering size.

21. Roses. (a) After ripening of rose seeds. Exposure of non-after-ripened seed of Rosa setigera serena to 65°F induced a secondary dormancy in embryos that were otherwise ready to grow. The embryos, after exposure to 65°F, required a low temperature after-ripening period that appeared longer than the usual stratification period for this species.

An experiment was set up to test the time and pre-storage temperature required to induce secondary dormancy of the embryo. Seeds of four rose species were used.

Seeds of 10 rose species were used to determine the compensating temperature. The temperatures being tested are 35°, 40°, 45°, 50°, 55°, 60°, and 65°F.



(b) Developing blackspot resistance. Seedlings from roses resistant to mixed inoculum of the blackspot organism were tested against single spore isolates of the fungus. Several progenies segregated for resistance to individual isolates of the fungus; selections are being selfed to establish true breeding lines for both resistance and susceptibility.

Inoculations were made monthly from cultures of the blackspot fungus maintained in several different ways, viz. on pea, potato, and rose extract agar, on infected, frozen rose leaves, and on isolated rose plants. Only the cultures from frozen rose leaves and the isolated rose plants retained virulence. These techniques will, for the first time, make it possible to test successive generations of rose seedlings against the same race of the pathogen.

(c) Cheyenne Rose plots. At Cheyenne, Wyo., the surviving plants in an old-established rose species block were propagated and the old block was discontinued.

22. Stocks (*Matthiola incana*). High seed yields were obtained when plants were grown in sand culture on low nitrogen (21 ppm) in combination with either no phosphorus or medium (39 ppm) phosphorus and high (156 ppm) potassium. High nitrogen (336 ppm) accompanied by abundant phosphorus and potassium results in vigorous vegetative growth that is unfavorable for seed production.

23. Viburnums. The Viburnum research collection has been expanded by an additional 59 accessions during the year. In August a trial planting of evergreen species was made in a protected oak woodland, which included 200 plants representing 110 accessions, consisting of 22 species, 11 hybrids, and 13 cultivars. Because of the severe winter conditions many of the plants were damaged or killed, and will need to be replaced. However, these climatic conditions provided a good screening test and several hardy forms have been selected for further study.

Of the 198 crosses made in 1962, 72 produced seed while only 12 of the 37 selfs produced seed. The seed produced from wide interspecific crosses is often only partially developed and the embryo may not germinate. These borderline hybrids can often be procured by embryo culture. To replace earlier casualties of nursery soil conditions, fifteen hundred plants have been propagated that will provide plants for the research program and the permanent display planting. Two V. carlesii hybrid seedling selections have been made and are being propagated for further trial.

## B. Diseases

1. Camellias. Drenches of Dexon (p-dimethylaminobenzenediazo sodium sulfonate) applied at approximately 1 month intervals to camellia plants growing in soil infested with Phytophthora cinnamomi (Camellia root rot) resulted in better plants than did drenches of SD 4741 (0,0,0-trimethyl phosphorothioate), SD 345 (2-propene-1, 1-dial diacetate), or Panogen (methyl dicyan diamide). The organism was not eliminated from the soil. This work was cooperative with the Georgia Agricultural Experiment Station.

2. Carnations. Heat treatment eliminated four viruses from the tip shoots of King Cardinal carnation. We are now testing plants containing the four viruses singly and together versus the virus-free King Cardinal for yield and for keeping quality. Commercial growers are now producing carnations free from viruses as well as free from fungus and bacterial diseases.

3. Chrysanthemums. The last of the aspermy- and mosaic-diseased chrysanthemums imported from Japan, Taiwan, and England have been heat cured and supplied to New Crops Research Branch for release. Attempts to heat-cure the rosette and stunt-diseased chrysanthemums were unsuccessful. English stunt, which is curable, is a distinct virus.

4. Easter Lilies. (a) Easter lilies freed from cucumber mosaic virus by scale propagation. Easter lilies recently infected with cucumber mosaic virus or with the lily ringspot virus were salvaged by propagation from outer scales. This procedure had no effect on the common lily mottle virus. Apparently the method succeeds with cucumber mosaic virus and with lily ringspot virus because these viruses have necrotic effects on the scale tissues and therefore move more slowly through these tissues than do the milder viruses.

(b) Bordeaux remains best control for botrytis blight of lilies. Control of botrytis on Easter lilies under field conditions favorable to botrytis was tested in 5 replicated plots this season. Botran, a new chemical recommended for botrytis, was inferior to standard Bordeaux and other chemicals used as controls. Only Bordeaux units retained living foliage at the end of the test. Cooperative with the Oregon Agricultural Experiment Station.

(c) The white freckles virus of Croft lilies may be causing a new disease in Ace lilies. A new fleck disease of Ace lily, developed recently, is termed mid-season fleck. This disease may be caused by white freckles virus of Croft entering Ace plantings. Cooperative with the Oregon Agricultural Experiment Station.

(d) Control suggested for stripe disease in Easter lily fields. The



stripe disease complex continues to be the most serious problem confronting Easter lily bulb growers in California and Oregon. During the last season, field observations and 15 series of plot and greenhouse experiments were made in cooperation with the Oregon Agricultural Experiment Station, to find a suitable field control. Some observations which may lead to control were: 1) The incubation period of the disease was approximately 18 months. For this reason it is impossible to reduce the disease by roguing the bulblet crop. As the mother crop is rogued for stripe, the residual amount evidenced in the bulblet crop is of no consequence. 2) Because of the long incubation period a grower whose soil and/or location has a high incidence of disease, can grow his bulblet crop to produce yearlings in some other location, then finish the commercials in his own soil. 3) Sample plantings of yearlings from 15 sources planted in 3 locations proved that the severe stripe form of the disease develops only in the principal lily areas of Oregon and California. Thus the tendency to develop easily rogued stripe plants was 50 times as great on the southern Oregon coast as in the Willamette Valley. 4) Some soils and/or locations near Portland had as much disease as in the coastal area but it was difficult to detect by greenhouse indexing. Although these practices permitted good control in the field (avoiding as much as \$5,000 an acre roguing costs), no control for the disease has been devised in greenhouse cultures.

Application of relatively new techniques in use of the electron microscope by cooperators at Oregon State University gave strong proof that the cause of stripe is a virus. Although tobacco rattle virus has twice been isolated from affected lilies, current data indicate the true cause was some other virus. Latest field data point to a soil-borne virus, and indicate that the cause was concentrated in scattered areas in fields in which all plants contracted the disease. Cooperative with the Oregon Agricultural Experiment Station.

5. Geraniums. (a) Verticillium infection of geraniums may be seed-borne. Verticillium infection of geraniums was re-investigated to establish whether or not the disease is seed-borne. More than 150 cloned seedlings from Verticillium-diseased mothers, when grown in supposedly sterilized soil, all contracted the disease. Cooperative with the Oregon Agricultural Experiment Station.

(b) The relation of essential elements to severity of geranium virus diseases. Studies were conducted on the relation of essential elements to expression of geranium virus symptoms. Low potassium failed in several tests to give the described purple-edged leaves attributed to potassium deficiency. Low magnesium has consistently favored development of leaf breaking virus symptoms. The work is cooperative with the Oregon Agricultural Experiment Station.

(c) Commercial control of important geranium virus diseases. Practical



control of krinkle and leaf breaking virus diseases of geranium was obtained by taking cuttings in summer when symptoms are not apparent. Summer temperature probably inhibited movement of the virus to new shoots. A large scale test on a mother block isolated on a mountain top near Palomar Mountain, San Diego County, Calif., was promising. Examination of this 15,000 plant test of plants from cuttings made in the summer showed no virus disease whatever. Re-indexing of this mother block by growing representative cuttings in a Portland greenhouse will be made to detect any residual disease. This work was cooperative with the Oregon Agricultural Experiment Station.

6. Gladiolus. (a) Transmission of some gladiolus viruses by cutting flowers and tops. In gladiolus the viruses of tobacco ringspot and bean yellow mosaic were transmitted by cutting flowers and by cutting tops preparatory to harvesting corms. Cucumber mosaic virus and the cowpea strain of bean yellow mosaic virus were transmitted by cutting flowers but not by cutting tops. Tomato ringspot virus was not transmitted by either method in our tests.

(b) Irregular expression of gladiolus virus symptoms. When gladiolus cultivars that express symptoms in leaves, flowers, and corms were inoculated mechanically with cucumber mosaic virus, these symptoms agreed closely. When infected with this virus by aphids, these symptoms segregated irregularly, presumably because of virus translocation variants. This work was cooperative with the Entomology Research Division.

(c) Failure of systemic insecticides to protect gladiolus against cucumber mosaic virus. Controlling cucumber mosaic in gladiolus by placing systemic insecticides in the row at planting was ineffective because the insecticide remained in the old corm. This work was cooperative with the Entomology Research Division.

(d) Gladiolus cormels free from cucumber mosaic virus from infected parent corms. Gladiolus corms infected with cucumber mosaic virus commonly yielded a fair proportion of cormels free from this virus. However, not a single cormel was reclaimed free from bean yellow mosaic virus by this procedure. The difference was attributed to the necrotic effects of cucumber mosaic virus on the tissues, and the consequent slowing of virus movement. It was desirable to check the cormels in an insect-free greenhouse, and to hold the cormels for a second year to permit all to germinate and to permit the leaf symptoms of cucumber mosaic to be expressed in all.

(e) Shading failed to make gladiolus more susceptible to cucumber mosaic virus. Shading gladiolus plants from 1 to 10 days failed to make them more susceptible than non-shaded plants to cucumber mosaic infection by mechanical inoculation or by aphid inoculation. This work was in cooperation with the Entomology Research Division.

7. Pyracantha. Heavy loss of pyracantha fruit in nurseries was found to be produced by Phytophthora sp. and Rhizoctonia solani with less damage caused by Glomerella cingulata and Fusicladium pyracanthae. This latter fungus is the only one previously reported on pyracantha fruit. This research was cooperative with the Georgia Agricultural Experiment Station.

8. Rhododendron and Holly. The cause of a canker and dieback disease of varieties of Ilex opaca was demonstrated to be caused by the fungus Botryosphaeria ribis. The same fungus had previously been found causing a dieback of Rhododendron. On Rhododendron, wounding was found necessary for successful infection. Two-months old wounds served as infection courts. Possible spread on pruning tools is being investigated. B. ribis isolates from Rhododendron, holly, and apple varied in their pathogenicity on Rhododendron. Pathogenicity increased in the order listed. Field trials with Dexon and Vorlex drenches to control Phytophthora root rot on Rhododendron are in progress. A laboratory screening technique, for evaluation of chemicals in control of soil organisms, is being developed. Cooperative with the Ohio Agricultural Experiment Station.

9. Roses. A suggested virus of tea roses from Thomasville, Ga., has not yet responded to heat. These plants are not infected by rose streak virus, as shown by grafting to indicator hybrid teas. It has not been proven that a virus causes the chlorosis and leaf drop. Under high temperature these roses turn black and die. When returned to the greenhouse bench just before the heat is fatal, they make a burst of apparently normal growth. Propagations from this apparently normal growth remained healthy for several months but then produced the original symptoms.

### C. Culture

1. Anthocyanin synthesis. A basic study was initiated to determine how anthocyanins are synthesized by plants. Since a portion of the anthocyanin molecule presumably is derived from acetate and the other portion from phenylalanine, both of these compounds labelled with C<sup>14</sup> were fed separately to red cabbage seedlings. By isotopic and chromatographic techniques compounds which have been labelled both from the labelled acetate and phenylalanine are being isolated. These labelled compounds presumably are intermediates formed during anthocyanin synthesis. If these intermediate compounds could be identified, we would have a better understanding of how anthocyanins are synthesized by plants.

2. Camellias and azaleas - growth retardants. Cycocel, B995 and phosfon drenches stimulated camellia flower bud formation on plants younger than they normally produce flowers. Satisfactory flowers resulted. Cycocel and B995 were also used as sprays. These materials



applied in August after the last pruning of three azalea cultivars produced better shaped plants and more flowers when they bloomed outside. Better shaped plants resulted when these retardants were applied in July, August and September to nine azalea cultivars for greenhouse forcing after cool storage. Slower flowering followed use of high concentrations or late applications of the retardants.

Azalea and camellia plants treated the previous year bloomed satisfactorily the second year. Treated azaleas showed dwarfing effect the second year even though they were placed in different containers.

Year-round flowering of azaleas was accomplished by use of growth retardants, Cycocel, B995 and Phosfon-D which checked shoot growth but permitted flower bud initiation. Short photoperiods or light intensity reduction of natural photoperiods tended to produce the same result. Dormancy-breaking cool storage was necessary for accelerated and uniform flowering.

3. Cut flowers - increasing longevity. The rate of maturation of freshly cut greenhouse roses was effectively decreased by treatment with ethylene oxide gas. Roses placed in an atmosphere of 0.25 percent ethylene oxide for 20 hours at 60°F, when removed to a room at 70°, fully opened in 70 hours, whereas those not treated fully opened in 40 hours. Present indications are that similar effects can be obtained by considerably decreasing the exposure time and increasing the concentration of the gas.

Future studies, in cooperation with Agricultural Marketing Service, will involve basic studies on the mechanism of action as well as a quantitative method for measuring less than 1ppm of ethylene oxide by gas chromatographic procedures.

Many problems lie in the way before practical consideration can be given to the use of ethylene oxide for increasing keeping quality of cut flowers. Time, rate, and temperature studies must be resolved for each variety of cut flower studies. An engineering problem will eventually arise for the construction of gas chambers and for the most efficient and practical method of obtaining the desired atmosphere. Since ethylene oxide is toxic at high concentrations as well as being highly flammable and reactive, procedures must be worked out for its safe handling and storage. The finding that ethylene oxide delays maturity may be the major breakthrough the florist industry has been seeking in its effort to find a method of increasing the keeping quality of cut flowers.

4. Cyclic lighting for controlling growth and flowering of photoperiodic plants. Plants of more than 60 different species were tested in their response to cyclic lighting -- a flexible system. Length of the light-dark cycle (1 to 30 minutes), the relative amounts of light

and dark in the cycle, and the type and intensity of the light can be varied. Stem elongation and flowering of long-day plants were accelerated more by incandescent light than by the same radiant energy from fluorescent light. Flowering of short-day plants was delayed more with 2 and 6 hours of fluorescent light than with the same number of hours of cyclic lighting from incandescent filament lamps. Cyclic fluorescent light failed to control flowering when given throughout the 16 hour night. Subjecting short-day plants to 4 hours of darkness after the natural short day before exposing them to a cyclic fluorescent light treatment inhibited flowering. This work was in cooperation with the Plant Physiology Pioneering Laboratory.

5. Garden annuals - growth control by use of foliar applications of growth retardants. Applications of B995 and Phosfon-S were effective as foliar applications to most flowering annual plants and many woody plants. B995 was effective in the range of 0.08 to 1.0 percent and the new structure of phosfon (Phosfon-S) was effective in the range of 0.01 to 0.1 percent. Since only 2 to 3 ml of the chemical was used to spray a plant, less material was used for the foliar sprays than for soil drenches.

6. Hydrangeas. Certain cultivars of hydrangeas are often undesirably tall for holiday markets. A new growth retardant, B995, (N-dimethylaminosuccinamic acid), developed by the Naugatuck Chemical Company, was found to control the height of hydrangeas during summer growth and also during forcing after cool storage.

7. Iris. (a) New glutamyl peptide from Wedgewood Iris. There have been numerous reports of the occurrence of B-alanine in an uncombined form in plants. The natural existence of the free amino acid has recently been conclusively proven by its isolation and subsequent crystallization as the pure product. B-alanine is known to exist in several compounds in which it is combined through a peptide bond, 4.g. carnosine and pantetheine. The isolation and crystallization of pure -L-glutamyl-B-alanine from Wedgewood iris bulbs was the first report of this peptide being present in biological material. The identification of this compound adds another to the rapidly growing list of -L-glutamyl peptides that have been discovered in the past several years.

(b) New temperature treatments for bulbous iris save time, speed flowering. Bulbous iris grown in Washington were found to tolerate without injury a heat curing temperature of 108°F for 6 days. Curing at 100° or 104° for 4 days accelerated flowering as much as did the standard treatment of 90° for 10 days. These higher curing temperatures did not reduce flower quality. The shorter treatments permit more efficient use of curing facilities and earlier export of the bulbs to foreign markets. This work was in cooperation with the Western Washington Experiment Station.



8. Lilies. (a) Herbicides. Use of herbicides, diuron and neburon, in Easter lily plantings gave satisfactory weed control when applied before emergence and twice during the growing season but not if either or both of the latter applications were eliminated. PCNB-ferbam as a bulb and scale dip or dust increased yields but only slightly more than other fungicides. Row spacing less than 6 inches lowered yields per bulb planted in field rows and methyl bromide fumigated beds. Fumigated beds produced much higher yields than those not fumigated, particularly of larger sized bulbs.

Bulbs potted and plunged outside for rooting produced more satisfactory pot plants when forced than those bulbs that were held in cool storage before potting. Potting at different dates did not affect forcing if the plants were brought into the greenhouse at the same time. Cooperative with the Georgia Agricultural Experiment Station.

(b) New growth retardant controls height of Easter lilies. Phosfon-D applied in relatively large amounts as a soil amendment or drench reduced height of forced Easter lilies but sometimes induced limber stems and yellowed leaves. A new retardant, Phosfon-S, was found to control height effectively without injury when applied as a foliar spray to Georgia, Croft, and Ace Easter lily cultivars.

(c) Natural growth inhibitors. Ferulic, sinapic, and p-coumaric acids as well as their glucose esters were isolated and identified from seeds and pericarps of the interspecific hybrid Lilium speciosum Thunb. 'Album' by Lilium auratum Lindl. The abnormal physiology of these seeds was ascribed to the relatively high concentration of free ferulic acid in these tissue and a possible limiting of the mechanism for detoxification by esterification.

9. Rhododendrons - initiation of flower buds following application of growth retardants and artificial light. Liners of 12 Rhododendron cultivars responded to soil applications of Phosfon-D (2,4-dichlorobenzyltributyl phosphonium chloride) and foliar applications of Phosfon-S (chemical name not available) and B995 (N-dimethylaminosuccinamic acid) by slowing growth and initiating flower buds 4 months after treatment. The plants were grown in the greenhouse on natural daylengths with artificial light from 10 p.m. to 2 a.m. The process of flower initiation was prevented by 8-hour days and reduced light intensity. When the minimum night temperature was 65°F, 2 to 4 months were required for development of the flower buds. The plants were then exposed to cool storage (50°F) with light, and were in bloom 6 to 8 weeks later.

#### D. Classification and Identification

1. Herbarium Collections. About 350 identifications of plants were made for other government agencies as well as 100 for the general



public. Over 200 sheets were received for inclusion in the permanent collection. Loans totaling 565 sheets were sent out and 135 borrowed.

2. Willows. An extensive review of Salix literature has been completed and synopses of characters as well as abstracts of other pertinent data prepared for the approximately 20 species of willows occurring in Nevada. As a result, all the pertinent characters are now compiled for each taxonomic entity. Previously the verification of observations in herbarium specimens was laborious and time consuming because of incomplete descriptions in standard reference books.

3. Taxonomy of Native Hollies. The native hollies at the Gray Herbarium, Harvard University, have been studied along with most of the other specimens of Ilex pertinent to the project. Over 4,000 sheets have been examined in the past year and a report is in course of preparation. Status of the North American hollies within the genus has been determined.

4. Hardy azaleas. Observations continued on the flowering sequence of azalea varieties in the permanent plantings of the Arboretum. The flowering sequence of 2,250 plants in 750 varieties has been recorded for 2 years and these observations will be continued for an additional eight years. Such observations will be used in conjunction with morphological studies of the same varieties towards development of standards for the identification of azaleas.

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## SHADE, ORNAMENTAL AND WINDBREAK TREE CULTURE, BREEDING AND DISEASES

Problem. Homes, farmsteads, and municipalities have huge sums invested in shade trees and windbreaks. Removal of dead trees is expensive in cities. Decades are required to replace mature trees killed by diseases. Diseases annually kill thousands of valuable shade trees. There is need to develop economical means of control. Costs of control measures now available are estimated at several million dollars per year and are increasing and there is need to develop more efficient controls including disease-resistant types of trees. Development of genetic resistance to tree diseases (as well as improvement in additional characters) is slow and there is need to provide well-planned long-term research as soon as possible. There are numerous leaf spot diseases of maples, and the causal organism of most is as yet unknown. Numerous diseases of still unknown cause continue to kill sweet gum, scarlet oaks, pin oaks, and white ash in home and ranch plantings and research is needed to determine the causes and develop controls. The climate of the Great Plains with its low rainfall, hot summers, and cold winters makes it difficult to establish woody plantings and research is needed to find methods of establishing woody plants under such conditions. Only certain types of trees can endure conditions of the Great Plains and are usable to reduce wind damage to many crops and farmsteads. Hardiness, species adaptation, planting distances, and arrangements, responses of plantings under different environments and the nature of conservation of moisture and soil by windbreaks require additional research. Lack of good protection from heavy winds has made farming in many sections of the Great Plains area a very hazardous occupation, and studies are needed to show the types, spacings, and effects of windbreaks on crop response.

### USDA PROGRAM

In Department research special attention is being given at Beltsville, Md., and Delaware, Ohio, to the search for chemical cures for trees affected with Dutch elm disease; and at Beltsville, Md., and Tifton, Ga., to chemical controls for mimosa wilt. Limited, but important research on diseases of live oak, especially live oak canker, and blight of sweet gum is done at Beltsville. At Beltsville, additional basic research is conducted to determine the nature of many other tree diseases of unknown causes. At Tucson, Ariz., studies are underway to control desert-plant diseases.

Limited breeding work is done at Woodward, Okla. Increased emphasis and expanded research is being given at Beltsville, Md., and Delaware, Ohio, to the program of developing elms resistant to Dutch elm and

phloem necrosis diseases and disease-resistant maples. Likewise, hybridization of mimosa trees to develop desirable trees resistant to mimosa wilt is done at Beltsville, and Tifton, Ga.

The culture and handling of shade trees and windbreak studies including research on methods of planting, distances, arrangements of plantings, testing for adaptation, and evaluation of windbreaks is a major part of the program at Mandan, N. Dak.; Woodward, Okla.; and Cheyenne, Wyo.

Research is being conducted under a contract with the College of Agriculture, University of the Philippines, on the host range and transmission of the cadang-cadang disease of coconut palm. The contract extends for 5 years, 1961-1966, and is the equivalent of \$13,243.64 in Philippine pesos.

The Federal scientific effort now devoted to this area totals 6.1 professional man-years divided as follows: diseases (3.0); breeding (1.1); culture (2.0).

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

##### A. Breeding

1. Elms. Over 2,600 seedlings of elm species or hybrids were tested for resistance by inoculation with Ceratocystis ulmi, the Dutch elm disease organism. High levels of resistance occurred in all seedlings of the compound cross Ulmus pumila x the hybrid U. hollandica x U. carpinifolia. The trees originated from crosses made about 7 years ago. Also a high level of resistance persisted in a 15-year-old selection of U. parvifolia which has now flowered for several years. The tree showed high tolerance to inoculations made in 1950, 1951 and 1952. It is being propagated for trials more extensively. Approximately 35 other trees showed sufficient resistance to warrant further evaluation. Of 26 sources of Dutch elm disease resistance, representing selections in former years and breeding stock received from the Netherlands, 10 have come into flower. Trees of the Dutch elm disease-resistant selection, Christine Buisman, planted at Prescott, Arizona, in the hope of inducing early flowering, have died or grown poorly and have not flowered. This work is cooperative with the Ohio Agricultural Experiment Station.

2. Windbreak Plants. At Mandan, N. D., trees and shrubs grown from seed collected in Kansas, Oklahoma, and Texas suffered considerably more winter injury than stock grown from seed collected in Nebraska and states to the North. Among latter group no significant differences in hardiness were associated with origin at ages varying up to 6 years. Many species which have been under test in pure stand for long periods suffered heavy killing back and loss as a result of the continued drought throughout the first 5 months of the year.



3. Mimosa. Further selections of wilt resistant mimosa seedlings growing in heavily infested soil were made at Tifton, Ga., in cooperation with the Georgia Agricultural Experiment Station.

4. Saguaro. An unexpected sudden freeze early in 1962 killed practically all of the supply of seedling saguaros. Studies were made of the pollination requirements of the organpipe under controlled conditions in a screen cage. The flowers proved to be self-sterile. Birds, bees, and bats were effective pollinators. Preliminary observations suggest that lack of seed production appears not to be a principal factor in decline of the organpipe stand at the Organpipe National Monument. Cooperative with the University of Arizona.

## B. Diseases

1. Elm. (a) Beltsville, Md. New studies were made of the effects of pentachloronitrobenzene (PCNB) on Ceratocystis ulmi and on the usefulness of the chemical as a soil additive for control of Dutch elm disease. In vitro tests showed that growth of C. ulmi was inhibited by PCNB at concentrations of  $10^{-2}$  or greater. Benzene extracts of leaves from elms growing in soil containing 1:1000 parts PCNB inhibited growth of C. ulmi in culture. Extract of leaves from small trees growing in soil containing 1:4000 parts PCNB did not inhibit in vitro growth of the fungus. However, PCNB at 1:1000 caused chlorosis and stunting of elms growing in the treated soil. Two-year-old seedling elms were planted in soil containing 1:2000 parts PCNB and later inoculated. The 28 inoculated trees had an average of 4 inches of dead stem and 46 inches of discolored wood. Checks growing in untreated soil had an average of 4 inches of dead wood and 56 inches of discolored wood. The treatment failed to control the disease.

Similar results were obtained in tests on elms growing in soil containing 20% hydrated lime and 1:2000 PCNB. Also, soil containing 20% hydrated lime alone failed to control dieback and discoloration. Moreover hydrated lime plus PCNB reduced growth at the above concentrations. PCNB was recovered from the soil 7 months after treatment. Failure of PCNB to control the fungus is attributed to a consistently insufficient concentration of the chemical in the vascular system. Elms were grown in a mixture of 80 parts soil and 20 parts hydrated lime. Growth was reduced and no significant control of Dutch elm disease was obtained.

An ultraviolet light technique was devised for detecting oxyquinoline benzoate in stems and leaves of treated elms. Oxyquinoline benzoate seems to have possibilities as a systemic for Dutch elm disease. Treatment of 3-year-old seedling elms at Beltsville with Cycocel or phosfon did not retard growth or induce precocious flowering.

(b) Delaware, Ohio. In cooperation with the Ohio Agricultural Experiment Station, research to gain an understanding of the nature and sources of disease resistance were continued. Inoculations into trees of Ulmus americana of different ages showed that systemic distribution of the fungus occurred in trees a few weeks to 4 months of age. However, no disease symptoms were produced and recovery of the fungus in culture declined during the first week following inoculation and failed after 6 to 8 weeks. Stem inoculations of 1-year-old trees produced severe foliar symptoms in 40% of the trees in 2 to 3 weeks. The rest developed little or no foliar symptoms although vascular discoloration developed and C. ulmi was recovered in culture from all parts of the stem. Rapid spread of the wilt fungus in invaded trees suggests means of distribution other than by simple growth.

Extracts from different age groups of Ulmus americana showed that those from 78-day-old or younger trees inhibited germination of C. ulmi; whereas similar concentrations from 9-12 month old and 4-5 year old trees did not. Dilution of inhibitory extracts stimulated growth of C. ulmi. The nature of the extractable factor and its role in juvenile resistance is being studied.

2. Mimosa. At Beltsville, Md., study of the effectiveness of mixtures of soil and hydrated lime on the control of mimosa wilt were expanded to include mixtures of soil and pentachloronitrobenzene (PCNB) and soil-lime-PCNB mixture. Mimosas died in the 20% soil-lime mixture, and grew poorly in 10% soil-hydrated lime formulation. In the 5% mixture mimosa grew well, but 80% of the seedlings planted in it died of wilt. In untreated soil 85% of the seedlings died. The soil-lime-PCNB mixture was phytotoxic. PCNB was recovered from the treated soil 6 months after treatment but less PCNB was recovered from limed soil than from unlimed soil. PCNB was not recovered from acetone extract of mimosa growing in the treated soil but when PCNB was added to extract of mimosa, a positive test for PCNB was obtained.

Results of measurements by the mercury displacement method of the length of open water conducting vessels, which varied from 20 to 83 cm, suggest that spores or other fungus fragments may be carried in the transpiration stream as is the case with the fungus causing Dutch elm disease.

Seedlings of mimosa were treated with Cycocel and phosfon and then transplanted to soil infected with the wilt fungus. Both chemicals dwarfed mimosa but the dwarfed plants developed the wilt.

3. Saguaro. Study of the physiology of Erwinia carnegieana and closely related bacteria in relation to their host range and pathogenicity to cacti was continued at Tucson, Arizona, in cooperation with the Arizona Agricultural Experiment Station and the National Park Service. The severe cold killed or injured large saguaros on mountains in the vicinity of Tucson. Many freeze-damaged saguaros later fell victim to the bacterial rot. The National Park Service reported increasing damage from bacterial rot of organpipe cactus in the Organpipe National Monument in southern Arizona. Erwinia carnegieana causes bacterial rot of both the organpipe and saguaro cacti.

4. Sweet gum. A bacterium was isolated consistently from the black streaks in the wood of sweet gum affected with blight. Twenty-five seedling sweet gums approximately 6 ft. in height and growing under protected conditions in the greenhouse were inoculated with fresh broth cultures of the organism in March. The trees were dissected in November. No symptoms of the blight were noted on the trees during the summer and no discoloration was found in the wood when the trees were dissected. The bacterium appears not to be pathogenic. The identity and physiology of the isolate is being compared in cooperative work at the University of Arizona with Erwinia carnegieana, the cause of saguaro rot.

At Beltsville, Md., greenhouse-grown sweet gum seedlings approximately 12 ft. in height and 1.5 to 2.0 inches DBH that were grafted or budded 4 years ago with scions or buds from diseased trees were observed for symptoms of blight. No symptoms of disease have been noted during the 4 years. The trees were dissected in November 1962. No discoloration of wood typical of blight was found and discoloration, which was not typical of the blight, was limited to a few inches around the grafting wounds. Scions from diseased trees have produced new growth with normal wood and leaves. Rooted cuttings from diseased trees continued to grow normally during their third year. There is yet no evidence that the blight is infectious.

5. Live oak. Canker of live oak, previously recorded only from Williamsburg, Va., was found on a few trees near Mobile, Ala. Importance of the canker around Mobile has not been determined. The canker fungus, Endothia parasitica, failed to produce cankers when smooth bark of 15 small, live oak seedlings were inoculated with it.



6. Coconut Palm. A rather extensive study has been made in the Philippines under contract using PL 480 funds of the host range of the cadang-cadang disease of coconut palms. Corn was found to be a potential alternate host of this disease. Attempts at mechanical transmission of the virus have failed to date, indicating an animal vector as a potential transmitting agent.

### C. Culture

#### 1. Windbreak Plants.

a. Mandan, N. D. Winter studies to determine the ability of field windbreaks and artificial barriers of different designs to reduce wind velocities below a soil erosive rate and to increase soil moisture for crop growth by trapping drifting snow showed the following: Windbreaks of 3 rows having a 50-60% density throughout their height, caused snow drift deposits up to 10 feet deep within a space of 40 feet of the windward row or within 15 to 20 feet on the leeward side of the belt. Turbulence and eddies created by the tree denseness and solid-wall-drift, picked up all snow beyond the drift area and carried it to the next obstruction. Water content of the drifts averaged  $1:2\frac{1}{2}$  giving a very high runoff potential on sloping land.

One-row windbreaks having a density of 10-20% in the lower part and 50-60% in the top three-quarters, caused uniform snow deposits 2 to 3 feet deep over a wide area. There was no evidence of wind turbulence on the leeward side. Warm temperatures in January over part of the area melted the snow, then bare areas later froze to death that prevented soil intake of moisture from the spring thaw of snow deposited on frozen ground. Studies showed no intake of soil moisture from such drifts that contained up to 5 inches of water. This points out the possible danger of water erosion from deep snow-drifts on rolling land.

Nursery stock that was graded into two or more size-classes at the time of lifting in 1941, continues to show marked differences in growth. Total growth of green ash, American elm, and Siberian pea-tree still reflect the size class as they were graded at time of re-planting, the smaller size class were still smaller than the large size class. Russian olive trees show the reverse, and the largest original selections are now the smallest. The difference in height and growth between size classes gets bigger each year. Survivals were good in all classes.

Trees and shrubs planted by varying spacing distances and cultural methods showed no changes over the previous year. Soil moisture was at the wilting point until mid-May when rainfall for the next 2 months was more than necessary to take care of all growth requirements.

Losses were minor. No significant differences were found in survival and growth at the end of the third season of four species of conifers originally fertilized at three different rates or treated with waxes to reduce transpiration. Cooperative work has been started with the Soil Conservation Service to study the relationship of soil type to survival and growth of farm shelterbelt trees. Preliminary surveys have been made in two counties by the Soil Conservation Service.

b. Cheyenne, Wyo. The new Dropmore elm spacing experiment is being maintained and annual rates on growth are being taken.

Six established single-row field windbreaks near Cheyenne have been located for future studies and evaluation.

At Cheyenne 24 new accessions have been added to the list of woody plants under test.

c. Woodward, Okla. A total of 2,503 shrubs and 3,672 trees were placed in cooperative windbreak plantings. Three thousand button-bush plants were furnished the U.S. Corps of Engineers for planting on sand dunes at Fort Supply, Oklahoma Reservoir. This plant has shown the most promise to make a good recovery after being covered with flood waters for several month intervals. At Woodward inspections were made of as many of the old cooperative windbreak plantings as available travel funds permitted. The superiority of evergreen rather than deciduous species continues to be demonstrated. Inspections of old windbreaks still indicate that plantings on extremely difficult sites have the highest survival when they are arranged so that they receive continuous cultivation and are furnished supplemental water during periods of drought.

At Woodward, Okla., temperatures of 86° and 90° were experienced during the month of February 1962. Fifteen days later the temperature dropped to 1° followed by 4° and 10° on succeeding days. Below freezing temperature persisted for 8 days. As a result of such sudden fluctuation in temperature many of the Chinese arborvitae show bark rupture at the ground level. In the summer of 1962 less than 1% of the injured trees died.

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## WEED AND NEMATODE CONTROL

### Crops Research Division, ARS

Problem. The control of weeds is a most critical economic problem in the production of flowers and many ornamental plants. The costs and losses from weeds can be reduced by finding more effective chemical, biological, mechanical, cultural and combination methods of control.

Plant-parasitic nematodes and associated diseases are in many locations limiting factors in the growth of flowers and ornamentals. It has long been known that severity of attack by certain fungi is greatly increased if nematodes are present; and nematodes have been known to be vectors of several plant viruses. There is a great need for less expensive, practical, and more efficient methods of controlling nematodes on flowers and nursery plants.

### USDA PROGRAM

The program of testing herbicides on horticultural crops at New Brunswick, New Jersey, involves use of these materials on field grown gladiolus and involves less than 0.1 professional man-years.

Basic and applied research on the control of nematodes on ornamental crops is conducted at Tifton, Georgia, and Madison, Wisconsin, and involves 0.7 professional man-years.

### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

#### Weed Control

Weed research on gladiolus at New Brunswick, New Jersey, has shown that CIPC, R-2061, amiben, and diphenamid will give all season control of annual weeds. Diphenamid at 6 lb/A and R-2061 at 8 lb/A caused significant reductions in yield of corms. None of the herbicides affected flowering or the color of flowers.

#### Nematode Control

In experiments at Beltsville, Maryland, ethylene dibromide in emulsifiable form was the most effective material for control of nematodes in established outdoor rose plantings. Injected around the roots of the plants at the rate of 200 lbs. of active ingredient per acre, there was no damage to the roses, while only 50 lbs. per acre was needed for satisfactory nematode control.

In experiments at Madison, Wisconsin, dagger nematodes (Xiphinema americanum) caused a decrease in root growth of seedlings of Colorado blue Spruce and Black Hills Spruce. When the plants were overwintered outdoors, none of the seedlings infected with 2500 dagger nematodes, and only 25% of those infected with 500 dagger nematodes, survived. The trees that did survive gained only about half as much in height and root weight as trees not infected by nematodes.

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INSECT CONTROL  
Entomology Research Division, ARS

Problem. Ornamental shrubs, flowers, and turf are subject to damage caused by a great variety of insects and mites. More effective and safer control measures are needed for many of these pests. More basic information on the ecology and biology including host plant preferences and distribution of aphids, beetles, mites, thrips and other pests that attack or transmit diseases to these plants is required to provide a sound basis for the development of practical, effective, and safe control measures. Insecticidal and cultural methods of control that will not affect adversely the growing plants or natural enemies of the pests or result in objectionable residues in soils are needed. The nature and cause of resistant strains of insects and mites and means to overcome or prevent their resistance to insecticides require continuing investigation. The role and use of biological control agents should be more fully explored and efforts made to synchronize or integrate biological control with insecticidal and cultural control methods. Ornamental plants resistant to insect attack should be developed. Controlled light or application of other physical factors as possible means of controlling greenhouse pests should be studied. Increased emphasis should be placed on the search for insect attractants, chemosterilants, and growth- or reproduction-affecting substances.

USDA PROGRAM

The Department has a long-range program of research on ornamental, flower, and turf insects. It involves entomologists, chemists, physiologists and insect pathologists engaged in both basic studies and applied research on growers' problems and on problems of concern to plant pest control and quarantine officials. Basic biology and nutrition studies at Beltsville, Md., and Farmingdale, N. Y., and research on insecticidal and cultural control at Beltsville, Md., Farmingdale and Geneva, N. Y., Moorestown, N. J., and Sumner, Wash., are cooperative with the respective State Experiment Stations. Much of the work at Beltsville is cooperative with the Crops Research Division. Biological control studies at Beltsville, Md., Moorestown, N. J., and Geneva, N. Y., are cooperative with the State Experiment Stations as are studies concerned with insect sterility, attractants, and other new approaches to control. Cooperation is maintained at Moorestown, N. J., and Geneva, N. Y., with the Northern Utilization Research Division at Peoria, Ill., on research to develop methods of mass production of milky disease. Evaluation of equipment for insect detection and control is carried on at Beltsville, Md., and Geneva, N. Y., in cooperation with the Agricultural Engineering Research Division and respective State Experiment Stations. Research on insect vectors of diseases is conducted at Beltsville, Md., and Sumner, Wash., in cooperation with the Crops Research Division and the Washington and Oregon Agricultural Experiment Stations.



The Federal scientific effort devoted to research in this area totals 6.2 professional man-years. Of this 0.6 man-year is devoted to basic biology and nutrition; 1.8 to insecticidal control; 1.1 to biological control; 0.6 to insect sterility, attractants, and other new approaches to control; 0.3 to evaluation of equipment for insect detection and control; 0.6 to insect vectors of diseases; 0.7 to insect control treatments for commodities regulated by plant quarantine; and 0.5 to program leadership.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

### A. Basic Biology and Nutrition

1. Insect Pests of Ornamentals. Mites resistant to insecticides had a thicker cuticle than normal mites in studies made at Beltsville, Md., with a Nitachi HU-11 electronic microscope. The electron micrographs of longitudinal and cross sections of the integument of the mites showed that the cuticle of a strain of organophosphate resistant two-spotted spider mite, Tetranychus telarius, is thicker than that of a nonresistant strain. The difference is apparently in the endocuticle component which was also thicker in the resistant forms (0.84 microns) than in the nonresistant forms (0.56 microns). The epicuticle and exocuticle of the 2 strains were of approximately the same thickness. Measurements of other components of the integument were also similar in the 2 mite strains.

In further tests with yellow water-pan aphid traps at Farmingdale, N. Y., twice as many aphids were caught in traps painted a deep yellow known as federal or safety yellow as were taken in traps painted a light or near lemon yellow color. Yellow sticky boards (6" x 12") set at intervals of 4, 8, and 16 feet trapped an average of 10.5, 9.3, and 8.2 aphids, respectively, per board.

Transient winged aphids, as evidenced by trap catches, were more abundant during July and early August than during April, May and June. Cucumber mosaic symptoms were present in many more gladiolus flowers in plantings made during June and July than in plantings made during late March, April and May. The late gladiolus plantings suffered the greater damage in confirmation of observations of commercial growers. There was a good correlation between movement of the winged aphids, the presence of young gladiolus plants, and subsequent development of cucumber mosaic. Gladiolus planted 1 to 7 feet from a source of the mosaic virus averaged 20% of the flowers developing symptoms. Plants grown 8 to 14 feet from a source of the virus averaged 12% of the flowers with symptoms.

2. Japanese Beetle. At Moorestown, N. J., a method for separating the sexes of the Japanese beetle in the pupal stage was developed. Male pupae have a three-lobed eruption on the ventral posterior segments formed during the development of the genital structures. This characteristic is not present on female pupae.

There is need for a practical procedure for rearing the Japanese beetle so that large numbers of all stages are available continuously throughout the year. At present research is restricted to those periods of the year when stages needed for studies occur naturally, and is confined largely to field-collected insects. In research to develop mass rearing techniques, most of the eggs introduced into steam-sterilized soil hatched but very few of the grubs developed. The development of third-instar grubs to the adult stage in both unsterilized and steam-sterilized soil was also disappointingly low, 25-30% and 9.5%, respectively.

## B. Insecticidal Control

1. Insects of Ornamentals. Tortricid leaf rollers, including *Platynota stultana*, occurring on greenhouse roses in New Jersey, Pennsylvania and Maryland, were not controlled satisfactorily with DDT, parathion, or more recently, with carbaryl. Commercially prepared emulsifiable concentrates containing 24 ounces of Zectran with or without 8 ounces of Korlan per gallon applied at 1 quart per 100 gallons of spray gave complete control of the larvae in webbed leaves. A few larvae survived treatment at half this strength. Potato aphids were also killed when Korlan was added to Zectran. In tests with DDVP aerosols, adult moths and partly grown larvae of leaf rollers were killed but not full-grown larvae or pupae. Indications are that two or three well-timed applications of Zectran or DDVP will be required to bring an established infestation under control.

Studies at Sumner, Wash., have provided basic information on the biology, ecology and methods for controlling the lily bulb thrips. This pest feeds on 33 species of lily but on no other plants. Practical methods of control include immersion of the bulbs for 1 hour in water at a temperature of 110° F. The addition of 4 teaspoons of formalin per gallon prevented the spread of fungus diseases among bulbs. Information on the biology and control of other insect pests of lilies was brought up to date for early publication in the lily yearbook.

Studies in Oregon and Washington conducted by the laboratory at Sumner, Wash., confirmed previous indications that the western lily aphid, the melon aphid and the foxglove aphid may be controlled on Easter lily by applying phorate at 4 pounds per acre or Di-syston at 2 pounds per acre in the furrow when bulbs are planted in the fall. These systemic insecticides protected bulbs until harvesttime the following fall.

DDVP in aerosols with methyl bromide as the propellant, when applied at Beltsville, Md., to 35 kinds of greenhouse ornamentals including the most widely grown crops caused no plant injury when the temperature was 70° F. or below. However, at 80° the treatment caused injury to certain chrysanthemum varieties. This high temperature is required for maximum effectiveness of parathion and other insecticides having lower vapor pressures. Injury which sometimes followed treatments made at 80° F. in commercial greenhouses at first was thought to be caused by epichlorohydrin,



a rust inhibitor incorporated in most commercially prepared aerosols. However, aerosol tests in an experimental greenhouse with DDVP alone or with epichlorohydrin indicated that the high temperatures at which treatments were applied were responsible for the injury.

In performance tests with greenhouse temperatures of 50, 60, or 70° F., DDVP at dosages of 1 pound of 10% aerosol per 50,000 cubic feet killed resistant spider mites, leaf roller, cabbage looper, citrus mealybugs, thrips, aphids, and whiteflies at all temperatures. DDVP treatments made at low temperatures will avert the possibility of plant injury and be advantageous to growers of cool temperature crops in situations where it is inconvenient to raise temperatures in greenhouses to those required for effectiveness of other aerosols.

Strains of green peach aphids in commercial greenhouses in several eastern States have developed the habit of feeding and reproducing on young leaves in the growing points of shoots of carnation and chrysanthemum, and in the opening flowers. Lindane, parathion, malathion, TEPP, and sulfotepp have not given satisfactory control when applied in aerosols or sprays. Better results were obtained with DDVP but for this treatment to be successful two or more applications must be made at 3- and 5-day intervals. In preliminary soil drench tests with systemic insecticides in Maryland on carnation in greenhouse benches, dimethoate, Bidrin, and Meta-Systox-R at 8 lb. per acre gave complete kill of aphids on carnation shoots and flowers in from 4 to 7 days. In tests with a resistant strain of two-spotted spider mites on carnations, these three chemicals also gave the best control.

In tests on infested chrysanthemum, Bidrin and Meta-Systox-R at 8 and 16 pounds per acre as a soil drench failed to kill aphids in growing points or in carnation flowers in a commercial greenhouse in Pennsylvania. Further tests are needed to determine the reason for ineffectiveness of these materials under certain conditions. Organic matter in the soil or relatively poor translocation of the systemic insecticide in chrysanthemums may be responsible.

Poinsettias often require insecticidal applications after bracts begin to show color. In tests made at Farmingdale, N. Y., on greenhouse poinsettias in flower, injury was caused by malathion wettable powder and emulsion concentrate sprays, endosulfan wettable powder and emulsion sprays, and by dimethoate emulsion spray. DDVP and endosulfan smokes were not injurious. DDVP smoke may be useful for spider mite, mealybug, aphid, and whitefly control and endosulfan for aphid and whitefly control on poinsettias in addition to the commonly used sulfotepp smoke.

Among systemics tested against gladiolus thrips, dimethoate at 8 lb. per acre, when applied in the soil at the root zone of gladiolus at the 4-leaf stage of growth, gave complete protection of gladiolus flowers from attack by gladiolus thrips. Other systemics, at 8-lb. dosages, gave less than 60% clean flowers. Poor results with these systemics may have been due to



poor root absorption since most of the current season foliage and flower growth of the gladiolus is derived from storage tissue in the planted corm.

2. Japanese Beetle. Unceasing expansion of the area of infestation continually brings to light new problems concerning this insect and its control that require additional research. In screening tests of repellent materials for control of the adult beetle at Moorestown, N. J., extracts of Acacia moniliformis and Schinopsis lorentzi sprayed on foliage caused some reduction in feeding, but neither extract was sufficiently repellent to be of value in protecting favored foliage. Hercules 8717 and Hercules 9699 were equally as effective as DDT in killing beetles and in protecting foliage. Zectran was somewhat less effective than DDT or carbaryl. When exposed to sunlight, Zectran deposits lost practically all of their toxicity within 4 hours. DDT lost some toxicity during 8 hours of exposure. The toxicity of carbaryl was not modified significantly during an 8-hour period. In another test the addition of a polyethylene to sprays of DDT, heptachlor, and lindane prolonged the toxicity of deposits of DDT and heptachlor for a few hours but had no effect on the longevity of lindane.

Carbaryl with or without a sticker afforded practically complete protection to peach foliage from injury by the Japanese beetle for 1 week after spraying when the rainfall was only 0.06 inch. During the second week when the accumulated rainfall reached 1.96 inches, residues of carbaryl lost about one-half of their protective value, but those resulting from application of carbaryl plus Rhoplex Resin B-15 and UCAR Resin WC-130, emulsifiable boiled linseed oil, emulsifiable blown linseed oil, and emulsifiable tung oil lost about one-fifth of their protective value during the second week. At the end of the third week, when accumulated precipitation reached 3.12 inches, an application of carbaryl alone gave little protection to the foliage, but when this material was applied with stickers from one-fifth to one-half of the protective value of carbaryl remained.

The compound 2-phenoxyethanol did not act as a detoxicant for DDT. Beetles that had fed for 24 hours on leaves sprayed with 2-phenoxyethanol were equally as susceptible to DDT as those that had fed previously on unsprayed foliage. The addition of 2-phenoxyethanol to DDT spray did not inhibit the insecticidal action of DDT.

In laboratory tests with third-instar grubs in Sassafras sandy loam, at 80° F., Shell 8436 had about one-twelfth, Zectran about one-fifth, UC 8305 about three-fourths, and Telodrin about ten times the toxicity of dieldrin to Japanese beetle grubs. Telodrin was the most toxic of the chlorinated hydrocarbon insecticides tested against grubs, but its usefulness may be limited because of high mammalian toxicity. When a Zectran dust was applied and left on the surface of bare soil, only 35% remained after 3 weeks. When it was mixed with soil there was little loss during 3 weeks and 25% of it remained after 8 weeks.

The influence of the mode of application and ground cover on the persistence of the chlorinated hydrocarbon insecticides applied to soil at the rates recommended for control of the grubs was investigated. Residues from dust formulation treatments were about the same as those from granular treatments. When the insecticides were applied as top-dressings and left on the surface of bare ground, bioassays showed that 50% of the insecticides remained after aldrin and heptachlor had been exposed for 5 days, chlordane for 9 days, and DDT, dieldrin and toxaphene for about 28 days. Only 2% of aldrin, 6.5% of heptachlor, and 16% of chlordane remained after an exposure of 28 days. Volatilization appeared to be the major factor in reducing insecticidal residues on the surface of the soil. Incorporating insecticides with the upper 3 inches of soil immediately after application greatly reduced their loss to the atmosphere. Fifty percent of the insecticides remained after heptachlor had been in the soil for 7 months, aldrin for 11 months, chlordane for 17 months, dieldrin for 54 months, and DDT and toxaphene for more than 84 months. Grass cover reduced appreciably the loss of compounds applied as top-dressings to established turf, probably due to diminished air movement close to the surface of the soil and lower temperatures compared with those characteristic of bare ground. Fifty percent of the insecticides remained in light turf 2 months after applications of aldrin, chlordane, and heptachlor; 80% of the dieldrin and 90% of the toxaphene remained at the end of the 2-month period. DDT was not tested in light turf. In moderate and heavy turf 50% of the insecticides remained 6 months after applications of aldrin, chlordane, and heptachlor, 22 months after a dieldrin treatment, 35 months after a toxaphene treatment, and 56 months after a DDT treatment.

Lack of precise chemical methods for determining small amounts of mixtures of chlorinated hydrocarbon insecticides in nursery soils prompted research to develop suitable bioassay techniques. A practical method of assay for these insecticides in soils that can be used at any time of the year has been developed with *drosophila* as the test insect. On the basis of this research the Plant Pest Control Division authorized in 1962 use of the *drosophila* bioassay procedure to determine effectiveness of treatments applied to nursery soils subject to the restrictions of the Japanese beetle quarantine. When the mortality of the flies exposed to a soil under standardized testing conditions was less than 50%, the toxicity of residues in the soil was not adequate to eliminate grubs. When the mortality of the flies was between 50% and 90%, the toxicity was sufficient to eliminate the next annual brood of grubs. When more than 90% of the flies were killed, the toxicity in the soil was sufficient to eliminate at least the next two annual broods of grubs.

Since the amounts of chlordane, DDT and dieldrin needed in soil to eliminate newly hatched European chafer grubs are somewhat less than the amounts required to eliminate the Japanese beetle, the bioassay technique may also be used to regulate chafer quarantine soil treatments. The Plant Pest Control Division authorized in February 1962 use of *drosophila* bioassay to evaluate toxicity to European chafer grubs of soil containing residues of chlordane, DDT and dieldrin.



Laboratory stocks of drosophila may vary in the speed of their reaction to chlorinated hydrocarbon insecticides in soil. Because of this, sassafras sandy loam containing known amounts of insecticides has been used as a standard to determine and compensate for this variation. The restricted occurrence of sassafras soils on the Coastal Plain of the Middle Atlantic States areas suggested the need for a more generally useful standard. The geographical limitation on the bioassay procedure was eliminated by substituting a filter paper pulp tablet containing 2.4 µg. of dieldrin to regulate drosophila exposures of less than 10 hours, a pulp tablet containing 0.27 µg. of dieldrin to regulate exposures of approximately 24 hours, and a tablet containing 0.12 µg. of dieldrin to regulate exposures of approximately 48 hours duration.

When screening tests were conducted to evaluate the possible value of new insecticides against Japanese beetle grubs, the reaction of drosophila to the more promising materials was also determined. The flies appeared to be satisfactory for assaying the toxicity of residues of Zectran, UC 8305 and Shell 8436, but carbaryl was only slightly toxic to them. However, when piperonyl butoxide was added as a synergist to soil containing carbaryl, the mortality of the flies was proportional to the amount of carbaryl in the soil.

3. European chafer. In studies at Geneva, N. Y., to find new insecticides to control chafer grubs in soil, the phosphate insecticide GS-4072 had little toxicity. Variable results were obtained in tests with Telodrin but its toxicity ranged from four to eight times that of dieldrin.

In studies to determine the minimum amounts of insecticides needed to kill newly hatched grubs in Farmington loam, less than 5% of the grubs transformed to second instars in soil containing 0.25 pound of aldrin, 1 pound of endrin, 0.125 pound of heptachlor, 0.5 pound of lindane, 4 pounds of carbaryl or 0.5 pound of endosulfan per 3-inch acre. Third-instar grubs died before pupation when this soil contained 0.25 pound of aldrin or heptachlor, 0.5 pound of dieldrin, or 1 pound of chlordane per acre.

Temperature of the soil had a profound effect on the amount of chlordane and dieldrin needed in Farmington loam to kill 50% of the third-instar grubs during an exposure of 2 weeks. When the temperature was reduced from 80° to 70° F., the amounts of these insecticides had to be increased about four-fold to maintain the same rate of insecticidal action as that at 80°. A drop in the temperature from 80° to 60° required about a ten-fold increase in amounts used. In Berrien fine loam, about a six-fold increase in the concentration of dieldrin was necessary to maintain the same speed of insecticidal action at 70° as at 80° and a sixteen-fold increase was required at 60°.



The comparative amounts of aldrin, chlordane, dieldrin and heptachlor needed to kill 50% of the third-instar grubs of the European chafer or third-instar grubs of the Japanese beetle during an exposure of 2 weeks at 80° F. were 0.08 lb. aldrin for the beetle, 0.11 lb. for the chafer; 1.02 lb. of chlordane for the beetle, 0.82 lb. for the chafer; 0.26 lb. of dieldrin for the beetle, 0.20 lb. for the chafer; 0.10 lb. of heptachlor for the beetle and 0.13 lb. for the chafer. From the close agreement in the dosages required for these grubs, it appears that both species are equally susceptible to aldrin, chlordane, dieldrin and heptachlor.

The speed of insecticidal action of a granular formulation of dieldrin when freshly applied against third-instar chafer grubs in Berrien fine sandy loam at the rate of 2.5 pounds of the toxicant per acre was definitely slower than when the same amount was applied as a dust, but after being in moist soil for 4 months, the granular formulation killed grubs more rapidly than the dust.

### C. Biological Control

1. Japanese Beetle. At Moorestown, N. J., a study to determine the relationship between the number of spores of Bacillus popilliae in the soil and the incidence of infection among third-instar grubs introduced into the soil, showed that practically all grubs surviving as long as 56 days in uninoculated soil pupated and only 6% became infected. A concentration of 50 million spores per kilogram of soil reduced pupation by 67%, one of 150 million spores by 87% and a concentration of 450 million or more spores per kilogram prevented pupation. One hundred percent infection among the grubs was obtained with 450 million spores per kilogram in 56 days at 82° - 85° F., with 1.35 billion spores in 52 days, and with 4.05 billion spores in 35 days. The results of this study indicate that applications of spores at the rate of 1.7 billion per square foot--equivalent to 450 million spores per kilogram in the upper inch of soil--should practically eliminate an annual brood of grubs before pupation, particularly if the spores are applied before eggs hatch.

The pathogen Bacillus popilliae was well established in asparagus and corn fields adjacent to a pasture in southern New Jersey where the milky disease had been colonized in 1936, 1.5 billion spores per kilogram being present in the soil in the upper 3 inches. Apparently the disease spread naturally into the cultivated fields. There were an estimated 7 million spores per kilogram of soil in the upper 6 inches of soil in the asparagus field and 30 million per kilogram in the corn field.

Cooperative experiments with the Plant Pest Control Division on the use of the milky disease bacteria in large-scale Japanese beetle control plots during 1959 and 1960, in which granular formulations containing spores were applied by airplane and ground equipment in Georgia, North Carolina and Ohio at rates of approximately 50 million and 100 million spores per square foot, resulted in establishment at all sites. However, by the end of 1962 the

pathogen had not built up as anticipated because of competing pathogens and chemical residues in the soil.

Intensive research on sporulation of the milky disease organism in order to develop a medium for mass production is being carried on by the Northern Utilization Research Division.

A survey of 29 sites in 6 counties in southern New Jersey and in southeastern Pennsylvania where Tiphia vernalis had been released several years ago and at one time was known to be established revealed the presence of this parasite only at Valley Forge State Park in Chester County, Pennsylvania. At other sites the parasite could not be detected by visual scouting. Therefore, T. vernalis is now a minor factor in controlling the grubs in areas where once it was an important one.

2. European Chafer. At Geneva, N. Y., no parasites were found at nine sites in western New York where parasites of the European chafer from Europe--Dexilla rustica, D. vacua, Microphthalma europea, and Tiphia femorata--were released during the preceding 10-12 years. It is yet to be demonstrated that any of these introduced parasites have become established.

Assays were made in the fall of 1962 of soil from thirty-two 1-acre plots, where spores of Bacillus popilliae had been applied as spot treatments in the fall of 1954 within an area of 24 square miles in western New York, in a cooperative program with the Department of Entomology of Cornell University. Assays were also made of soil from areas adjacent to the plots. There has been a progressive decline in the density of populations of chafer grubs since the colonization of the pathogen. This could not be attributed to the pathogen, however, because only an occasional infected grub was found. There has been no significant change in the pattern of infection of the European chafer by milky disease since 1957. The incidence of infection among the grubs has remained low and at about the same level within inoculated plots and in the areas adjacent to them.

Assays were also made in the fall of 1962 of soils from small-scale plots where the pathogens Bacillus popilliae and B. lentimorbus were colonized in 1954 and in 1960. The chafer grub populations at the sites treated in 1954 have also remained low, but the assays show that the pathogens were spreading slowly in an irregular pattern from the original plots. Grub populations at the sites treated in 1960 have remained so low that there has been no opportunity for the pathogens to become established.

A study was made of the virulence of different strains of the pathogens Bacillus popilliae and B. lentimorbus to third-instar chafer grubs. A low level of infection was obtained with spores of B. popilliae produced in grubs of Cyclocephala sp., Phyllophaga anxia, and the Japanese beetle. However, when spores originally produced in P. anxia, P. fusca, or P. hirticula and then passed through chafer grubs, were again introduced



into chafer grubs, they were highly virulent. Spores of this pathogen obtained from naturally infected chafer grubs were also highly virulent to chafer grubs. The standard strain of B. lentimorbus would not infect chafer grubs, but a high level of infection was obtained with this strain after it had passed through a chafer grub, and also with the Maryland strain of the pathogen.

In cooperative studies with the Department of Food Science and Technology of the New York Agricultural Experiment Station at Geneva, the relationship between germination of spores of Bacillus popilliae produced on brain-heart infusion agar and the ability of the spores to produce infection in third-instar chafer grubs was investigated. When suspensions of 1,000 spores with ability to produce colonies on the medium ranging from 1.9 to 45.0% were injected into the grubs and incubated at 80° F., there was a trend for the incidence of infection among the grubs to increase progressively with germinative ability of the spores on the medium. After incubation for 4 weeks, the injection of 19 germinative spores produced infection among 53% of the grubs, and the injection of 450 of these spores produced infection among 85% of the grubs, confirming results obtained early in 1962.

#### D. Insect Sterility, Attractants, and Other New Approaches to Control

1. Ornamental Insects and Mites. Spider mites were successfully sterilized with apholate dips without causing damage to the host plants. Untreated females of the two-spotted spider mite (Tetranychus telarius) mated with males dipped in 0.0125% apholate in alcohol-water solutions, produced male progeny and dead eggs, but no female progeny. Females exposed to 2% apholate dip produced no viable eggs. Apholate-treated males were competitive with normal males in mating with virgin females. Adult females, fed on plant foliage previously dipped in 1% aqueous apholate, ceased egg laying after a few days and became sterile. Most adult males that fed for 24 hours on the treated plants were sterilized. Females similarly fed on residues and then mated with normal males, laid fewer eggs. These produced fewer male and fewer female progeny and numerous dead eggs. Some of the female progeny were sterile even though reared from eggs laid on untreated foliage. The sterilizing ability of apholate residues on foliage persisted for at least four days. Three parathion-resistant strains and one nonresistant strain of T. telarius and the nonresistant T. cinnabarinus varied only slightly in their susceptibility to apholate.

In studies of the effects of gamma radiation on the fertility of two-spotted spider mites and their progeny, untreated female mites mated to irradiated males produced fewer females as dosages were increased from 8 to 28 kr. Untreated females mated to males exposed to 32 kr produced only males and dead eggs. Females exposed to gamma radiation and mated to untreated males produced fewer females as the dosage was increased from 1 to 24 kr, and after exposure to 32 kr produced no females.



2. Japanese Beetle. Preliminary tests conducted at Moorestown, N. J., with apholate, tepa, and metepa as chemosterilants for the Japanese beetle, suggested that the topical application of 25 µg of either apholate or tepa will sterilize males. When the treated males were mated with virgin females, eggs that were produced did not develop. On the other hand, metepa used at the same dosage did not prevent completely the development of eggs.

3. European Chafer. In tests at Geneva, N. Y., the most effective chemically-baited trap for capturing chafers was one painted red and baited with a 3:1 mixture of Java citronella oil and eugenol. A more attractive lure is needed. In tests completed during the year, not one of 707 synthetic chemicals tested as lures was outstanding in its attractiveness to the chafer. Compound ENT-30,512 and N-butyl sorbate had about the same attractiveness as the Java citronella oil-eugenol bait. The results with N-butyl sorbate confirm those obtained with the compound previously. N-butyl sorbate, while definitely attractive to the European chafer, had little attraction to the Japanese beetle. In surveys for the chafer in Japanese beetle areas, the Plant Pest Control Division uses N-butyl sorbate since this lure catches fewer Japanese beetles. The chafer was not attracted to extracts of unmated male and female chafers.

A black light fluorescent lamp with a peak emission of 3650 angstroms was much more attractive to the chafer than lamps emitting shorter or longer wave lengths. In a 4-year study with black light traps in competition with each other, or operated independently, effectiveness increased progressively as the wattage of the lamps increased from 4 to 8, 15, 20 and 30 watts. About three-fourths of the chafers were captured by these traps from dusk to midnight; none were captured after dawn. When the effectiveness of a 6-watt black light trap was compared with that of a 15-watt black light trap, both operating independently on 12-volt batteries, the 6-watt trap caught three-fourths as many chafers as the 15-watt trap when chafer flight was heavy, and one-half as many when the flight was light. In spite of its lower efficiency, the 6-watt unit shows considerable promise for use in survey operations because it could be operated for 10 nights on a single charge in comparison with only 3 nights for the 15-watt unit. When populations of chafers were very low, black light traps captured some chafers even when none was seen in flight. During a 10-night period when one chafer was seen in flight on one evening and one on another evening, black light traps captured one or more chafers on 8 of the 10 nights.

#### E. Evaluation of Equipment for Insect Detection and Control

1. Japanese Beetle. In the survey program for the Japanese beetle, a 0.5-inch torch wick has been used for many years to dispense the anethole-eugenol attractant. A woven dental roll does not fray as readily as the torch wicking. In comparative evaporation tests at Moorestown, N. J., the same amount of attractant was dispensed by a

0.5-inch dental roll as by the 0.5-inch torch wick, indicating that the woven dental roll may be substituted for the torch wick.

2. European Chafer. In comparative tests at Geneva, N. Y., the same amount of N-butyl sorbate was dispensed by a 0.5-inch dental roll and by a 0.5-inch torch wick when both were exposed 1/8 inch above the cap of the bait bottle. Either type of dispenser may be used in the survey program for the chafer.

The attractiveness of black light to unwanted nocturnal insects presents a problem in practical usage of this trap to detect chafer infestation. In the more southern areas where populations of nocturnal insects are larger than in western New York, the 3/4-inch opening of the funnel in the standard trap became clogged by large insects. Placing a disk of 1/2-inch mesh hardware cloth in the funnel prevented clogging of the orifice and reduced the volume of extraneous insects in the receptacle by about 40% without modifying the numbers of chafers the trap captured.

#### F. Insect Vectors of Diseases

1. Insects of Ornamentals. The green peach aphid transmits amaryllis mosaic. Pronounced green and yellow mottle symptoms, large ringspots and chevron patterns in amaryllis leaves suspected for many years to be symptoms of a virus infection, have been duplicated in healthy seedling amaryllis with inoculations of sap and in transmission tests with the green peach aphid. In experiments, conducted over the past two years, in cooperation with the Crops Research Division in Maryland, the virus was transmitted mechanically and with aphids to tobacco, and other indicator plants in which it produced symptoms identifying it as a strain of cucumber mosaic virus. The problem has been difficult to solve because amaryllis develops new foliage quickly and normally at only one season of the year; and also because of the time required to grow healthy seedlings under isolation for inoculation tests and subsequent observations of symptom expression. Identification of the malady in amaryllis as a virus and determination of its mode of transmission has furnished a basis for making recommendations for control to commercial amaryllis growers and home owners in many parts of the country.

Sunn hemp, Crotolaris juncea, a plant being evaluated at Glen Dale, Md., as a new crop source for paper pulp, developed leaf mottle and severe stunting symptoms in 1961 and 1962 that later were proved to be caused by a strain of bean yellow mosaic virus. The green peach aphid was a highly efficient vector of this disease in greenhouse tests. From 50 to 100% of exposed plants became infected. Since the disease is a nonpersistent aphid-borne virus, any migrating aphid could be expected to transport the virus from outside sources or transmit it within the crop. Sunn hemp has a long season of susceptible vegetative growth and is severely stunted when infected with bean yellow mosaic virus. The successful culture of this crop will be limited to areas devoid of this virus in plant reservoirs or where few migrating aphid vectors occur during the growing season.



# G. Insect Control Treatments for Commodities Regulated by Plant Quarantine

1. Japanese Beetle. There is a continuing need for improved treatments for nursery stock and farm products to eliminate infestations of the Japanese beetle to permit their movement without danger of spreading the pest. Research on the development and improvement of these treatments is conducted at Moorestown, N. J. When the treatments of balled and potted plants with ethylene dibromide formulation 440 or with ethylene dibromide-chlordane formulation 431 were revised in 1961, the application of these formulations was limited to those periods of the year when only grubs were present in the soil, largely because there had been little demand by the growers for treatments during the late spring and the summer. Since these treatments were effective in tests conducted during the year in eliminating not only the grubs, but the eggs, pupae, and adults in the soil, it was recommended to the Plant Pest Control Division that the seasonal limitation on these treatments be removed.

The possibility of treating samples of soil to destroy noxious insects before shipment to a laboratory for bioassay with drosophila as the test insect was explored. Fumigation with ethylene dibromide or methyl bromide was not satisfactory because residues of the fumigants, which were toxic to the flies, were not eliminated by aeration for 5 days. Heating the soil caused a loss of chlorinated hydrocarbon insecticides. Quick freezing where the temperature was reduced within a few hours to -15° F. had no effect on the insecticidal residues. The quick freezing procedure is a simple and practical method for eliminating all stages of the Japanese beetle and grubs of the European chafer.

Bioassay of soil from a commercial nursery where an insecticide-fertilizer mixture had been applied showed that the insecticide was well distributed through the soil by an initial cultivation followed by the usual cultural operations.



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## II. MARKETING AND ECONOMIC RESEARCH

### MARKET QUALITY

#### Market Quality Research Division, AMS

Problem. The rapid increase in production of field grown narcissus, gladiolus, lilies, stocks, and chrysanthemums into a multimillion dollar business in Florida, California, and North Carolina has raised many problems in marketing. Information on methods and materials for use in packaging, on the temperature requirements for storage and in transit, and on the prevention of decay are among the most urgent problems. Information is also needed on methods to prevent berry and leaf abscission and berry decay of greens, such as holly and mistletoe.

#### USDA PROGRAM

The Department has a very limited program in market quality research on cut flowers and ornamentals, amounting to approximately 1.0 professional man-year. This research is conducted at the Fresno, Beltsville, and Chicago laboratories. The work on quality maintenance during transportation is conducted in cooperation with the California Floral Traffic Conference.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

##### A. Quality maintenance in handling and packaging

1. Mistletoe. Studies to determine the effectiveness of certain chemicals for the prevention of berry and leaf abscission of packaged mistletoe were continued in Chicago. Mistletoe twigs, when dipped in 20 ppm solutions of 2,4,5-T or alpha naphthalene acetic acid, or in 50 and 100 ppm solutions of N<sub>6</sub> benzyladenine, had less than 1 percent berry and leaf abscission after holding 14 days at room temperature. None of these materials were phytotoxic.

Berry decay was effectively controlled for 14 days at room temperature by dipping the mistletoe twigs in 2000 ppm Dithane M-45, Botran, or Hyamine 3500 prior to packaging in 140 MSP or 300 MST cellophane bags. One-hundred ppm of 2-amino butane was slightly less effective and was also slightly phytotoxic. By adding 2,4,5-T or alpha naphthalene acetic acid to the fungicidal solution, leaf and berry abscission were also controlled. (MQ 2-15)

##### B. Quality maintenance in storage



1. Pine Seedlings. The Forest Service sometimes stores pine seedlings in commercial storages also used for table grapes. Consequently, the seedlings may be exposed to low concentrations of sulfur dioxide. The Service has experienced some poor stands of young trees that they believe resulted from exposure to  $\text{SO}_2$  during storage.

In tests at Fresno, Calif., exposure to 2500 ppm  $\text{SO}_2$  for 2 hours at weekly intervals severely damaged Ponderosa seedlings held 50 days at  $32^\circ \text{F}$ . On planting after storage, the leaves and many roots died within 3 weeks. At 1000 ppm growth was retarded, but the plants recovered. Slight retardation occurred at 100 ppm. Very little damage occurred at 10 ppm  $\text{SO}_2$ .

Use of a fungicidal dip and storage in a polyethylene bag appeared promising as an improved handling method for pine seedlings. This technique saved the storageman the time and expense of wetting down the seedlings at intervals during storage and also was effective in retaining moisture around the roots. Captan and Botran dips caused no injury, but Harvan retarded growth. Decay was not a problem in any of the particular lots tested. (MQ 2-15)

#### C. Quality maintenance during transportation

1. Cut Flowers. Air shipping tests with flowers have shown that transit times, from packing in California to delivery at wholesale, range from 18 to 35 hours. Flower temperatures during transit were mostly in the  $50^\circ$  to  $70^\circ$  range, but extremes of  $90^\circ$  and  $34^\circ$  were observed.

Solutions to the problem of reducing losses in transit appear to lie in improved packaging to protect flowers from temperature extremes, refrigerated holding rooms at points where movement of flowers is delayed, and in modified atmospheres to supplement the limited refrigeration available. To test this latter solution, roses were held under various combinations of nitrogen, oxygen, and carbon dioxide for simulated transit or storage times.

An atmosphere of nitrogen with 0.5 or 1.0 percent oxygen significantly retarded bud opening and loss of red color in Better Times roses at  $32^\circ$ ,  $37^\circ$ ,  $59^\circ$ , and  $70^\circ \text{F}$ . The respiration rate of roses held in these atmospheres at  $32^\circ$  for 2 to 3 weeks averaged 13 ml  $\text{CO}_2/\text{kg-hr}$ , compared to 17 ml for those in a normal atmosphere at the same temperature. The respective rates at  $59^\circ$  were about 56 ml, compared to 98 ml  $\text{CO}_2/\text{kg-hr}$ . Atmospheres of pure nitrogen (zero  $\text{O}_2$ ) damaged the roses.

Carbon dioxide at 5 or 10 percent levels in combination with 0.5 percent oxygen plus nitrogen at  $59^\circ \text{F}$ . for 40 hours retained color better than the same  $\text{O}_2$  concentration without  $\text{CO}_2$ . However, holding roses 3 weeks at  $32^\circ$  in 10 percent  $\text{CO}_2$  and 0.5 percent oxygen caused injury.

Polyethylene bags were used to maintain modified atmospheres under simulated transit conditions. After 40 hours at 59° or 70° F., an atmosphere of about 2 percent O<sub>2</sub> and 4 percent CO<sub>2</sub> developed around roses packed in 1½ mil polyethylene bags, flushed with pure nitrogen before sealing. If a packet containing 50 grams of hydrated lime was placed in the bag, the carbon dioxide level was reduced to almost zero. The same procedure used with 2 mil polyethylene bags resulted in low-oxygen injury to the roses. However, flushing the bags before sealing, with a mixture of 2.0 percent oxygen and 98 percent nitrogen (rather than pure nitrogen) prevented injury--the oxygen level was about 0.7 percent after 40 hours. Without hydrated lime, the CO<sub>2</sub> increased to 6.0 percent, but did not adversely effect the quality under these conditions of time and temperature. (MQ 2-15)

#### D. Postharvest physiology

1. Ethylene Oxide Studies. Ethylene oxide appears to counteract the aging and ripening effects stimulated by ethylene. Ethylene oxide causes a reversible inhibition of ripening in tomatoes and plums, retards the opening of cut roses and prevents "sleepiness" in carnations normally induced by ethylene. The antagonistic effect of ethylene oxide on ethylene provides direct evidence for considering ethylene as a hormone.

Better Times roses, held for 20 hours at approximately 60° F. in an atmosphere containing 0.25% ethylene oxide, had 1 to 1½ days longer life than untreated roses. Carnations held in a tight chamber developed "sleepiness". Treatment with 1 ppm of ethylene produced severe "sleepiness". Addition of ethylene oxide to provide a concentration of 0.2% in the atmosphere surrounding the flowers prevented all symptoms of "sleepiness" in both chambers. Many tissues are very sensitive to injury by ethylene oxide and may require a very narrow concentration range and careful temperature control to obtain beneficial results. (MQ P-1)

## PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Quality Maintenance During Transportation.

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Postharvest Physiology.

Asen, Sam and Lieberman, M. January 10, 1963. Ethylene Oxide Experimentation Aimed at Cut Flower Longevity. The Florists' Review, Vol. CXXXI, No. 3398. (MQ P-1)

Asen, Sam and Lieberman, M. August 29, 1963. Ethylene Oxide Found to Combat Deterioration of Carnations. The Florists' Review, Vol. CXXXII, No. 3431. (MQ P-1)



ECONOMICS OF MARKETING  
Marketing Economics Division, ERS

Problem. Most agricultural processing industries are experiencing rapid and drastic changes in their market organization and practices. These changes are affecting both farmers and consumers. Research is needed to keep abreast of such changes and to indicate their probable consequences. There have been substantial advances in recent years in increasing efficiency and reducing costs through adoption of new technology in producing, assembling, processing, and distributing farm products. However, for producers and marketing firms to remain competitive additional information is needed on margins, costs, economics of scale and efficiencies possible in the marketing of farm products.

Marketing research also is increasingly concerned with evaluating present and prospective programs pertaining to agriculture, such as the Food Stamp Program and Federal Grading Activities and to the changing structure of market industries as this may influence the bargaining power of farmers. Research also is being directed to the economics of transportation and storage activities of both private firms and government. Increasing attention is being given to the longer-term outlook for various products and markets as an aid in better assessing the prospects for increasing industrial employment under the Rural Development Program and in assessing prospective interregional shifts in the areas of production and marketing for specific products.

USDA PROGRAM

The Department has a continuing long-term program involving agricultural economists, economists, and personnel with dual economic and technical training engaged in research to determine the reasons for the changes that are taking place in marketing so that ways can be found to increase the efficiency of the marketing system and make it more responsive to changing public needs. This research covers all economic aspects of marketing from the time products leave the farm until they are purchased by ultimate consumers.

Work has recently been started on the evaluation of merchandising and promotion practices for floral products in cooperation with and partially financed by the Florists Telegraph Delivery Association.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Merchandising and Promotion

Evaluation of Merchandising and Promotion Practices for Floral Products. Work is being initiated to develop profiles of the floral industry, including availability, movement, and characteristics of markets and consumers of floral products; appraise existing merchandising, promotion, and management practices; and evaluate the effectiveness of alternative merchandising and promotional activities so as to expand and strengthen the demand for floricultural products. This work will be conducted in cooperation with the Florists' Telegraph Delivery Association which is financing a part of the research effort.

## PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Merchandising and Promotion

Hoofnagle, William S., July 9, 1963. Problems in Merchandising and Promoting Floral Products. Presented before USDA Seminar on Floral Product Research.







